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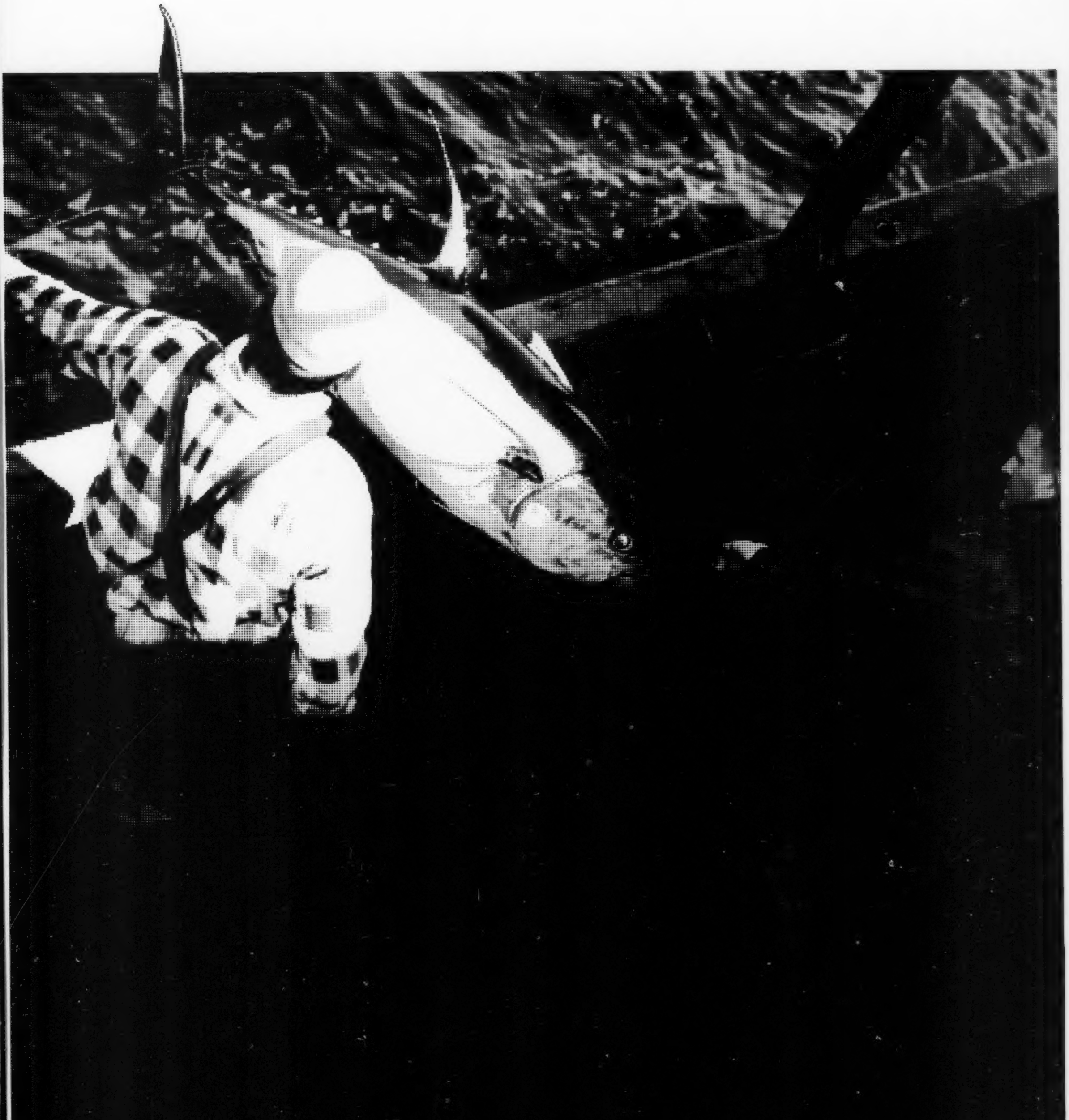

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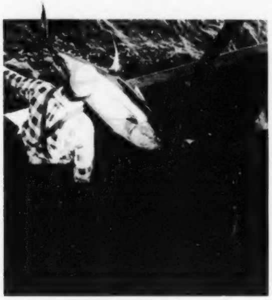

On the cover: Landing a 120-pound yellowfin tuna.

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A Review of Indian Ocean Fisheries for Skipjack Tuna, *Katsuwonus pelamis*, and Yellowfin Tuna, *Thunnus albacares*

WESLEY W. PARKS

Introduction

Skipjack tuna, *Katsuwonus pelamis*, and yellowfin tuna, *Thunnus albacares*, together comprise the most important component of Indian Ocean tuna catches. Catches of these species by Indian Ocean fisheries have been increasing over the last decade and totaled 262,300 metric tons (t) in 1986 (Fig. 1; Table 1). Skipjack tuna was the most important species at 32 percent of the total tuna catch in 1986; yellowfin tuna was the second most important at 25 percent. Skipjack tuna are found throughout the Indian Ocean from the Gulf of Arabia in the north to lat. 40°S (Fig. 2)[1]. Yellowfin tuna are also distributed throughout the ocean to about lat. 50°S.

This paper reviews information on fisheries for skipjack and yellowfin tuna in the Indian Ocean. The report is based almost exclusively on working papers presented at the Expert Consultation on the Stock Assessment of Tunas in the Indian Ocean held in December 1986 (Anonymous, 1987c). Additional information was taken from statistical publications of the United Nations Food and Agriculture Organization's Indo-Pacific Tuna Development and Management Programme (IPTP) (Anonymous, 1988a; Anonymous, 1988b).

The Fisheries

Skipjack and yellowfin tuna have become increasingly important in Indian Ocean tuna fisheries; their proportion in the total Indian Ocean tuna catch increased from 35 percent in 1974 to 56 percent in 1986 (Fig. 1). The catch of these species in 1986, 262,300 t, was three times the 1981 catch. Although some of this increase is attributable to increased catches by traditional small-scale fisheries, the major part is due to catches by the large-scale purse seine fleet which began to take a significant part of Indian Ocean tuna catches in 1983. The purse seine catch increased from near zero in 1981 to 132,000 t in 1986 and accounted for 50 percent of the total Indian Ocean catch of skipjack and yellowfin tuna in 1986.

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Increases in catches of skipjack and yellowfin tuna in the Indian Ocean have been particularly great since 1982. Total skipjack catches increased gradually (33 percent) over a period of 8 years from 39,500 t in 1974 to 52,600 t in 1982 (Fig. 1). Over the same period, yellowfin catches increased 65 percent (from 28,300 t to 46,800 t), and catches of all tunas increased 45 percent. Then, during the 4-year period between 1982 and 1986, skipjack catches increased 181 percent to 148,100 t as the large-scale purse seine fishery was established and then expanded. Catches of yellowfin, the other principal species taken in the purse seine fishery, increased 144 percent during the period, while catches of all tunas increased 64 percent.

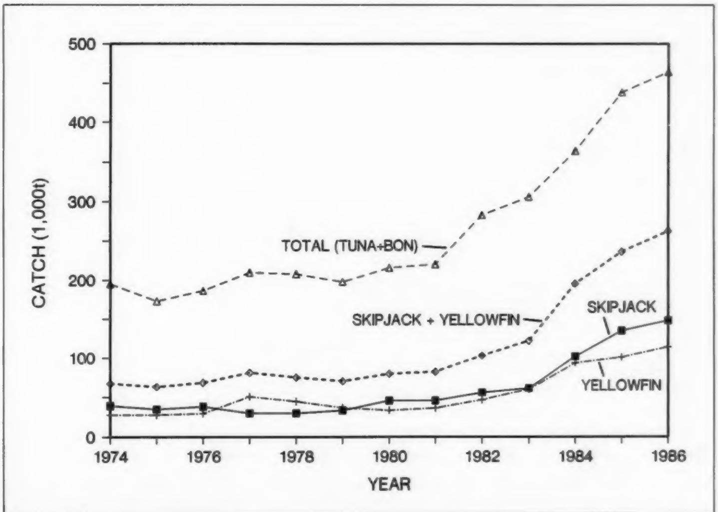
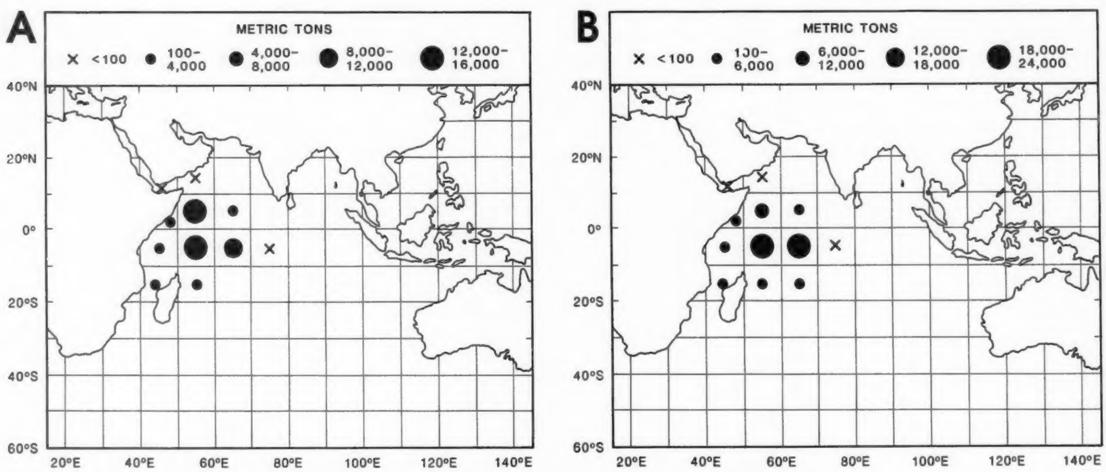


Figure 1.—Catches of skipjack and yellowfin tuna and of all tunas and bonitos in the Indian Ocean, 1974-1986 (Anonymous, 1988b).

[1]Figure 2 shows areas of skipjack tuna catches by the large-scale purse-seine fishery between lat. 20°S and 20°N. Catches by Indian Ocean small-scale fisheries, for which comparably detailed area data are not available, suggests availability from the Gulf of Arabia to lat. 40°S.

Table 1.—Catches (t) of tuna in the Indian Ocean, by species, 1974-1986 (Anonymous, 1988b).

	Catch (t)												
Species	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Yellowfin	28,297	28,330	30,090	50,898	44,683	36,982	34,064	36,435	46,828	60,663	93,503	100,768	114,243
Bigeye	21,183	30,959	23,659	31,511	47,379	31,027	31,303	32,378	39,144	44,168	35,604	41,949	42,904
Albacore	14,964	5,361	6,170	9,713	16,653	16,211	11,637	13,233	23,205	17,180	15,119	9,628	25,358
Southern bluefin	30,543	21,273	26,866	26,395	17,122	16,944	24,205	26,065	29,136	36,741	30,163	28,002	21,908
Skipjack	39,502	35,165	38,612	30,294	30,461	33,916	45,835	45,792	52,620	61,594	101,922	134,994	148,110
Longtail	2,126	2,421	3,046	3,305	1,936	4,589	3,215	5,710	15,337	15,957	16,329	28,962	21,570
Kawakawa	15,832	16,756	16,529	15,019	9,660	14,480	8,282	23,113	25,507	21,322	29,080	25,978	28,369
Frigate	0	0	0	0	0	0	0	0	0	0	0	2,466	1,626
Bullet	0	0	0	0	0	0	0	0	0	0	0	617	67
Frigate/bullet	6,006	4,057	2,708	3,086	1,661	1,701	1,595	2,908	4,967	5,675	9,337	3,418	10,942
Bonita Indo-Pacific	0	0	0	0	0	0	0	0	0	0	0	2,762	0
Tunas	36,476	28,616	38,578	39,738	38,431	41,965	55,558	34,369	46,048	42,810	33,232	58,876	49,337
Total	194,929	172,998	186,258	209,923	207,986	197,815	215,694	220,003	282,792	306,110	364,289	438,420	464,434



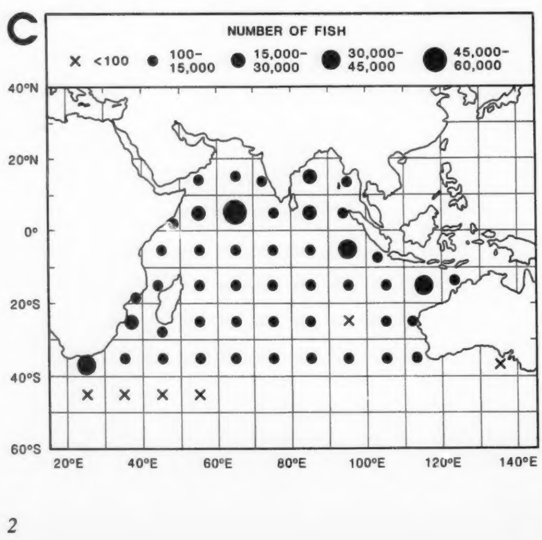


Figure 2.—Catches by area in the Indian Ocean in 1984: A = purse seine catch of skipjack; B = purse seine catch of yellowfin; C = Japanese and Taiwanese longline catch of yellowfin.

At least 34 nations fish for tuna in the Indian Ocean. Of these, 18 recorded catches of skipjack and 19 recorded catches of yellowfin tuna in 1986 (Table 2). Indian Ocean tuna fisheries can be grouped into two major sectors: Large-scale (in the Indian Ocean sometimes referred to as "industrial") and coastal small-scale ("artisanal") fisheries. In 1986, large-scale fisheries took 57 per-

Table 2.—Catches (t) of skipjack and yellowfin tuna, and total catches in the Indian Ocean by flag of fishing vessel, 1974-1986 (Anonymous, 1988b).

Species and country	Catch (t)												
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	19?	1985	1986
Skipjack tuna													
Australia	133	523	404	26	49	58	37	0	0	0	0	550	550
China (Taiwan)	39	83	42	18	5	11	9	20	11	9	22	36	29
Comoros	250	300	250	300	300	300	300	300	330	340	350	360	360
France	0	0	0	0	0	0	0	210	771	10,075	25,517	33,084	40,363
India	0	0	0	0	0	0	0	1,803	2,399	1,801	3,488	3,276	3,195
Indonesia	447	3,925	5,513	4,034	4,093	6,524	7,573	6,579	11,832	12,458	10,447	9,602	10,954
Ivory Coast	0	0	0	0	0	0	0	0	0	0	5,112	3,197	175
Japan	31	23	16	4	919	3	484	30	5	595	2	556	567
Kenya	0	0	0	0	0	0	0	71	97	33	45	63	49
Korea	72	200	63	151	253	65	43	48	57	8	0	0	0
Maldives	22,159	14,858	20,092	14,342	13,824	18,136	23,561	20,617	15,881	19,701	32,049	42,602	45,445
Mauritius	0	0	0	0	14	51	994	1,731	2,417	1,396	2,850	2,026	1,853
Mozambique	0	0	0	0	0	0	0	0	0	60	154	80	80
Pakistan	0	0	0	0	0	449	134	446	5,156	733	694	0	105
Panama	0	0	0	0	0	0	0	0	0	0	1,462	2,990	4,606
Seychelles	50	10	10	20	10	10	0	0	0	0	0	0	0
South Africa	0	0	0	0	0	0	0	0	0	13	0	4	0
Spain	0	0	0	0	0	0	0	179	14	0	8,079	22,854	24,877
Sri Lanka	12,321	15,243	12,222	11,399	10,994	8,309	12,700	13,758	13,250	13,972	11,619	12,118	13,737
United Kingdom	0	0	0	0	0	0	0	0	0	0	20	1,589	1,155
Yemen Dem.	0	0	0	0	0	0	0	0	400	400	12	7	10
Subtotal	35,502	35,165	38,612	30,294	30,461	33,916	45,835	45,792	52,620	61,594	101,922	134,994	148,110
Yellowfin tuna													
Australia	0	0	0	3	15	28	34	0	8	18	41	43	42
China (Taiwan)	800	523	425	4,733	3,261	2,878	2,723	1817	3,526	4,211	1,369	5,099	9,313
Comoros	100	100	100	100	100	100	100	100	110	120	130	140	140
France	0	0	0	0	0	0	0	260	1,224	10,773	33,611	32,231	35,519
Indonesia	1,071	869	1,317	2,345	2,811	3,236	3,348	3,350	3,740	5,888	4,247	4,543	3,270
Iran	0	0	800	0	0	341	322	0	0	0	0	0	0
Ivory Coast	0	0	0	0	0	0	0	0	0	0	5,107	3,046	562
Japan	4,415	4,719	2,744	2,061	4,263	2,023	3,440	4,701	6,355	7,232	7,467	9,372	11,115
Kenya	0	0	0	0	0	0	67	171	204	322	0	0	0
Korea	11,563	11,694	12,840	31,383	25,165	17,788	12,537	11,777	18,654	15,337	9,895	12,017	14,891
Maldives	4,128	3,774	4,891	4,473	3,584	4,289	4,229	5,284	4,004	6,241	7,123	6,066	5,321
Mauritius	0	0	0	0	15	5	1	1	0	1,057	1,284	914	851
Mozambique	0	0	0	0	0	0	0	0	0	15	188	15	15
Pakistan	0	0	0	0	0	0	0	0	0	0	0	0	2,093
Panama	0	0	0	0	0	0	0	0	0	0	2,441	3,236	3,432
Seychelles	150	100	50	80	100	128	357	949	518	157	198	147	10
Spain	0	0	0	0	0	0	0	363	55	0	13,796	15,411	17,532
Sri Lanka	6,070	6,611	6,915	5,720	5,369	6,168	6,906	7,662	8,350	9,046	6,439	6,716	7,977
Tanzania	0	0	0	0	0	0	0	0	0	0	0	0	600
United Kingdom	0	0	0	0	0	0	0	0	0	0	155	1,177	1,050
Yemen Dem.	0	0	0	0	0	0	0	0	80	80	12	511	510
Subtotal	28,297	28,390	30,090	50,898	44,683	36,982	34,064	36,435	46,028	60,663	93,503	100,768	114,243
Group total YF + SJ	63,799	63,555	68,702	81,192	75,144	70,898	79,899	82,227	98,648	122,257	195,425	235,672	262,353

Table 3.—Catches (t) of tuna by small-scale and large-scale fisheries in the Indian Ocean by species in 1986 (Anonymous, 1988b).

Fishery	Catch (t) by species[1]											
	YFT	BET	ALB	SBF	SKJ	LOT	KAW	FRI	BLT	FRZ	BIP	TUN	Total
Small-scale	20,126	179	0	0	73,935	21,435	28,369	0	0	12,635	0	43,300	199,979
Large-scale	94,117	42,725	25,358	21,908	74,175	135	0	0	0	0	0	6,404	264,822
Total	114,243	42,904	25,358	21,908	148,110	21,570	28,369			12,635		49,704	464,801

[1]Abbreviations: YFT = yellowfin; BET = bigeye; ALB = albacore; SBF = southern bluefin; SKJ = skipjack; LOT = longtail; KAW = kawakawa; FRI = frigate; BLT = bullet; FRZ = frigate/bullet; BIP = Indo-Pacific bonito; TUN = not identified to species.

cent of the total catch of tunas, 50 percent of the skipjack, and 82 percent of the yellowfin catch (Table 3). Small-scale fisheries took 43 percent of the total tuna catch, 50 percent of the skipjack, and 18 percent of the yellowfin catch.

No Indian Ocean tuna fishery catches skipjack or yellowfin tuna exclusively, but rather a mix of pelagic species that

may change both within and between seasons is harvested. While yellowfin typically comprises no more than 50 percent of the annual tuna catch of any single Indian Ocean fishery, skipjack is the most important of the tunas in catches of many fisheries, particularly the small-scale fisheries. In 1986, 90 percent of the total catch of tunas, tuna-like fishes, and billfishes was comprised of, in decreasing order of catch, skipjack tuna, yellowfin tuna, king mackerel, *Scomberomorus cavalla*; bigeye tuna, *Thunnus obesus*; kawakawa, *Euthynnus affinis*; albacore, *T. alalunga*; southern bluefin tuna, *T. maccoyii*; longtail tuna, *T. tonggol*; and tunas of unrecorded species.

The principal yellowfin-catching fisheries are the large-scale longline and purse seine fisheries which, in 1986, took 32 percent and 51 percent, respectively, of the total yellowfin catch. The principal skipjack fisheries are the large-scale purse seine fishery and the small-scale fisheries which each took 50 percent of the 1986 skipjack catch. Longline catches of skipjack are negligible.

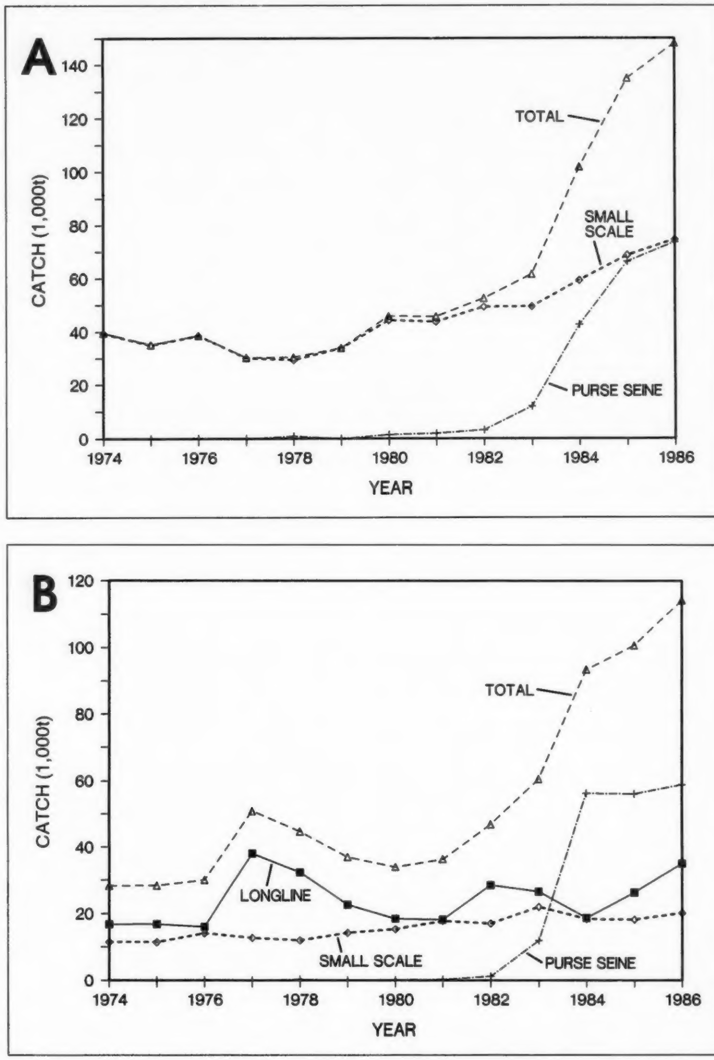


Figure 3.—Catches by fishery in the Indian Ocean 1974-1986: A = skipjack; B = yellowfin.

Large-scale Fisheries

Vessels in large-scale Indian Ocean tuna fisheries are typically long-range vessels primarily of distant-water fishing nations (DWFN). There are two major large-scale components: One is the longline fleets of Japan, Korea, and Taiwan; the other is the purse seine fleets primarily of France and Spain.

The large-scale longline fishery took 32 percent of the 1986 catch of yellowfin. Following the beginning of the fishery in the early 1950's, annual catches varied between 25,000 t and 70,000 t until 1973, when catches declined to around 15,000 t (Anonymous, 1987a). Between 1974 and 1986, yellowfin catches varied between 15,000 t and 40,000 t, reaching 36,000 t in 1986 (Fig. 3B).

Japanese longline vessels began fishing for tunas in the Indian Ocean in the early 1950's, followed by vessels from Taiwan and Korea in the 1960's (Amarasiri and Joseph, 1987). These large (200-500 GRT) longliners target yellowfin and other large tunas. In 1984, the longline fleet operated in virtually the entire Indian Ocean from lat. 45°S north to the Gulf of Arabia and between the coast of East Africa to Indonesia (Fig. 4). In 1985, 250 Japanese, 62 Korean, and 127 Taiwanese longliners operated in the Indian Ocean (Anonymous, 1987b; Indian Ocean Fishery Commission, 1985).

The longline fishery catches other large pelagic species besides yellowfin tuna—albacore, bigeye tuna, southern bluefin tuna, and billfishes. In 1986, yellowfin tuna composed 34 percent of the total longline catch. The Japanese longline fleet in recent years has targeted bigeye and southern bluefin tuna. In 1986 the catch of yellowfin tuna was 11,000 t, 26 percent of the total Japanese catch of

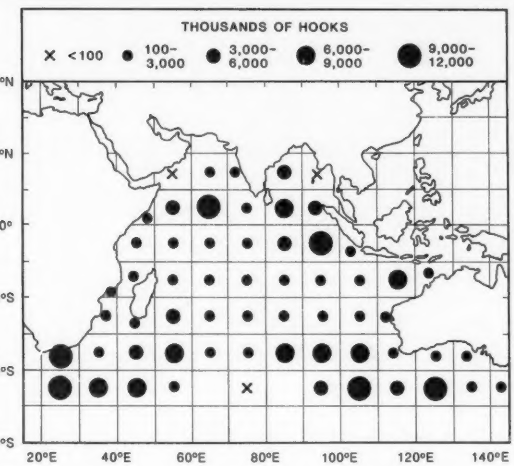


Figure 4.—Effort by the large-scale longline fishery by area in the Indian Ocean in 1984 (Anonymous, 1988a).

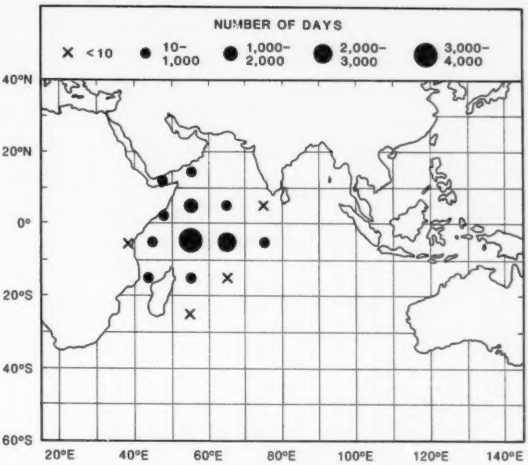


Figure 5.—Effort by the large-scale purse seine fishery by area in the Indian Ocean in 1984 (Anonymous, 1988a).

tunas and billfishes (Table 2). Korean longliners target yellowfin tuna, which in 1986, at 14,900 t, comprised 47 percent of the Korean catch. The Taiwanese fleet targets albacore and, in 1986, caught 9,300 t of yellowfin tuna, 20 percent of the total.

The large-scale purse seine fishery took 50 percent of the total 1986 catch of skipjack and 52 percent of the catch of yellowfin tuna. Catches of skipjack and yellowfin tuna were first recorded for this fishery in 1978 (1,147 t) and remained at low level through 1982 (4,400 t; Fig. 3). Beginning in 1983, catches increased rapidly to 132,000 t in 1986 (73,000 t skipjack, 59,000 t yellowfin).

The purse seine fishery became a significant presence in the Indian Ocean in the early 1980's when French and Spanish interests relocated large purse seiners from fishing grounds off the west coast of Africa to the western Indian Ocean. Exploratory purse seining in 1981 and 1982 suggested that commercial operations in the Indian Ocean would be successful (Steguert and Marsac, 1986). Subsequently, the French purse seine fleet in the western Indian Ocean grew to 27 vessels by 1985. The Spanish followed the French into the western Indian Ocean fishery in 1984 with 16 vessels. In the early years of the fishery the fleet operated near the Seychelles Islands. The fishery developed rapidly, and by 1985 the fishery, composed primarily of French and Spanish vessels plus some from Ivory Coast, Mauritius, Panama, and the United Kingdom, had expanded to cover the whole of the western part of the Indian Ocean, moving seasonally from the southern Arabian Sea to the Mozambique channel (Indian Ocean Fishery Commission, 1985). In 1984, purse-seine effort was concentrated between Madagascar in the south and the mouth of the Red Sea in the north and between the coast of East Africa and long. 70°E (Fig. 5).

The purse seine fishery catches a variable mixture of skipjack and yellowfin tuna and minor quantities of other tunas. In 1986, catches by the fleet were 53 percent skipjack, 43 percent yellowfin, and 4 percent other species, primarily bigeye tuna. In 1986, French catches of skipjack and yellowfin tuna were 40,300 t and 35,500 t, 50 and 44 percent, respectively, of the French total (Table 2). Spanish catches were 24,800 t skipjack and 17,500 t yellowfin, 58 and 41 percent, respectively, of the Spanish total.

Activities of the principal European participants in the purse seine fishery, France and Spain, are governed by fishing agreements between the Seychelles Government and the European Economic Community (EEC) to fish in the EEZ (Anonymous, 1987b). Seychelles-based vessels operate both in and outside the Seychelles EEZ. They transship catches at the port of Victoria where they also provision and resupply. The number of purse seiners operating out of the Seychelles reached a maximum of 49 at the end of 1984 (Anonymous, 1987b). In 1986, some of the vessels also fished in the Atlantic Ocean, leaving an average of 35 vessels fishing in the western Indian Ocean at any given time.

The EEC has also arranged access for member nations with other Indian Ocean nations (e.g., Madagascar and Mozambique; Anonymous, 1987b). Victoria, Seychelles, and Antananarivo, Madagascar, are the two major ports used by the fishing fleet. Vessels shift ports with season depending on fishing conditions in adjacent areas.

Small-scale Fisheries

The small-scale sector of the Indian Ocean tuna fisheries is composed primarily of coastal fishing vessels of Indian Ocean coastal nations. Traditional small-scale fisheries for tunas have operated in

Table 4.—Catches (t) of tunas by countries having small-scale fisheries in the Indian Ocean by species in 1986 (Anonymous, 1988b).

	Catch by species[1]												
Country	YFT	BET	ALB	SBF	SKJ	LOT	KAW	FRI	BLT	FRZ	BIP	TUN	Total
Bangaladesh	0	0	0	0	0	0	0	0	0	0	0	67	67
Comoros	140	0	0	0	360	0	1,300	0	0	0	0	140	1,940
Djbouti	0	0	0	0	0	0	0	0	0	0	0	30	30
Egypt	0	0	0	0	0	0	0	0	0	0	0	300	300
India	0	0	0	0	3,195	185	18,116	0	0	8,485	0	2,780	32,761
Ipdonesia	3,270	0	0	0	10,954	0	0	0	0	0	0	21,600	35,824
Iran	0	0	0	0	0	11,710	1,870	0	0	326	0	0	13,906
Israel	0	0	0	0	0	0	0	0	0	100	0	0	100
Kenya	0	0	0	0	49	0	0	0	0	0	0	0	49
Maldives	5,321	0	0	0	45,445	0	1,071	0	0	1,779	0	415	54,031
Mauritius	190	179	0	0	0	0	0	0	0	0	0	400	769
Mozambique	15	0	0	0	80	0	0	0	0	0	0	280	375
Oman	0	0	0	0	0	0	0	0	0	0	0	11,728	11,728
Pakistan	2,093	0	0	0	105	3,275	1,225	0	0	18	0	3,535	10,251
Reunion	0	0	0	0	0	0	0	0	0	0	0	190	190
Saudia Arabia	0	0	0	0	0	0	0	0	0	0	0	264	264
Seychelles	10	0	0	0	0	0	323	0	0	0	0	0	333
Sri Lanka	7,977	0	0	0	13,737	0	1360	0	0	1367	0	4	24,445
Tanzania	600	0	0	0	0	0	0	0	0	0	0	70	670
Thailand	0	0	0	0	0	1,895	0	0	0	0	0	1,497	3,392
U.A.E.	0	0	0	0	0	3,973	1,396	0	0	540	0	0	5,909
Yemen A.R.	0	0	0	0	0	307	438	0	0	0	0	0	745
Yemen Dem.	510	0	0	0	10	90	1,270	0	0	20	0	0	1,900
Total	20,126	179			73,935	21,435	28,369			12,635		43,300	199,979

[1]Abbreviations: Same as in Table 3.

coastal areas for over 100 years and, in some instances (e.g. the Maldives), perhaps for 1,000 years[2]. These fisheries land the entire Indian Ocean catch of small tunas and, in recent years, about half the catch of skipjack and 20 percent of the catch of yellowfin (Yesaki, 1987; Sivasubramanian, 1987).

Catches by these small-scale fisheries were first estimated for 1972 and have increased from 80,000 t in 1972 to 200,000 t in 1986 (Yesaki, 1987). Between 1974 and 1986, catches of skipjack and yellowfin increased from 50,000 t to 94,000 t (Fig. 3). Skipjack are taken more often in coastal fishing areas used by small-scale fisheries, and catches of skipjack increased more than catches of yellowfin. Skipjack continue to be the more important component of catches of these fisheries.

The principal small-scale tuna fishery nations in the Indian Ocean are India, Indonesia, the Maldives, and Sri Lanka. The principal nations catching skipjack and yellowfin—Indonesia, the Maldives, and Sri Lanka—took 92 percent of all small-scale fishery landings of these species in 1986. Skipjack made up 30 percent (11,000 t) of the total Indonesian catch of tuna in the Indian Ocean in 1986; yellowfin made up 9 percent (3,270 t, Table 2). The tuna catch of the Maldives was 84 percent (45,400 t) skipjack and 10 percent (5,300 t) yellowfin; the catch of Sri Lanka was 56 percent (13,700 t) skipjack and 33 percent (8,000 t) yellowfin.

The quality of data on the activities of small-scale Indian Ocean fisheries is improving, due in large part to the IPTP efforts, but problems still exist. Data for these fisheries are probably not as complete or accurate as data for large-scale fisheries, especially for years before 1982 when IPTP began. Catches recorded by IPTP for India seem low considering the great number of vessels estimated for India. However, most of the vessels are nonmechanized and even primitive (e.g. little more than logs tied together) and take very few tuna.

Also misleading are statistics showing small-scale fisheries that seem to develop or disappear "overnight." This is probably not real and most likely reflects improvement in statistics-gathering arrangements, which are often coordinated by IPTP (e.g. Pakistan, Table 2).

Of the 23 nations whose small-scale fisheries caught tuna in 1986, 9 reported catches of skipjack and 10 reported catches of yellowfin (Table 4). Five nations—India, Indonesia, the Maldives, Pakistan, and Sri Lanka—had skipjack or yellowfin catches greater than 1,000 t. In 1986, fisheries of these nations took 79 percent of the total small-scale fishing landings of tuna, 95 percent of small-scale landings of skipjack, and 96 percent of all small-scale landings of yellowfin. While skipjack is important in the tuna catches of India, Indonesia, the Maldives, and Sri Lanka, yellowfin is important only in Sri Lanka where it composed 25 percent of the total tuna catch in 1986 (Table 4; Maldeniya and Joseph, 1987).

Compared to the large-scale fisheries, small-scale Indian Ocean fisheries are very heterogeneous and even less directed at any particular species (for a detailed description see Steguert and Marsac, 1986). Most catch a mixture of small yellowfin, skipjack, and other small tunas. In 1986, catches were 37 percent skipjack, 14 percent kawakawa, 11 percent longtail tuna, 10 percent yellowfin, and 22 percent unclassified. Indian Ocean small-scale fisheries vary considerably in all aspects from vessel size and sophistication to target market. In some, vessels are small, unpowered,

[2]Joel Nageon de Lestang, Director, Resource Management, Seychelles Fishing Authority, P.O. Box 449, Fishing Port, Mahe, Seychelles. Personal commun., August 1989.

Table 5.—Estimated numbers of tuna fishing vessels by gear type[1] for various countries in the Indian Ocean in 1984 (Yesaki, 1986).

	Mechanized				Nonmechanized			
Country	GN	PL	T	PS	PL	T	Unclass.	Total
India	2,362	263		221			133,019	135,865
Indonesia	1,188		2,237	260				3,685
Iran	1,464							1,464
Maldives					561	3,115		5,003
Oman								
Pakistan	274							274
Somalia								
Sri Lanka	2,541							2,541
Thailand	30			153				183
U.A.E.								
Yemen Dem.								
Total	7,859	1,590	2,237	634	561	3,115	133,019	149,015

[1]Abbreviations: GN = gillnet; PL = pole and line; T = troll; PS = purse-seine.

Table 6.—Estimated tuna catch (t) by gear type[1] for various countries in the Indian Ocean in 1984 (Yesaki, 1986).

	Mechanized				Nonmechanized			
Country	GN	PL	T	PS	PL	T	Unclass.	Total
India		3,037						3,037
Indonesia			8,009	7,004				15,013
Iran	13,615							13,615
Maldives		50,602			416	2,495		53,513
Oman								
Pakistan	3,951							3,951
Somalia								
Sri Lanka	24,980							29,490
Thailand	52			7,317				7,369
U.A.E.								
Yemen Dem.								
Total	42,598	53,639	8,009	14,321	416	2,495		121,478

[1]Abbreviations: Same as in Table 5.

and constructed of wood, and the fishermen use hand gear. Catches are sold informally at beach landing sites. In others, vessels are larger, more sophisticated in design, and made of fiberglass. Operators of these vessels fish with mechanized gear and deliver to ports where catches are processed in modern facilities, and the product is exported. Most vessels are between 7 and 25 m in length; major fishing gears include gill net, pole and line, troll, purse seine, and longline. Gillnet is the most commonly used gear. According to a 1984 survey, gill nets were used by an estimated 50 percent of small-scale fishing vessels for which gear was recorded (Yesaki, 1987; Table 5). The same survey found that 44 percent of the tuna catches for which gear could be determined in 1984 was taken by pole-and-line gear (Table 6).

Discussion

Economic Considerations

In recent years, skipjack and yellowfin tuna have comprised about 50 percent of the total catch of tunas in the Indian Ocean. Since Indian Ocean tuna fisheries are virtually all mixed-species fisheries, it is impossible to discuss economic considerations for skipjack and yellowfin fisheries separately. Consequently, the following relates to all Indian Ocean tuna fisheries.

Each of the two major sectors of the Indian Ocean tuna fishery, the large-scale and the small-scale, operates under a different set of economic considerations. In addition, a third entity, the coastal, resource-adjacent nation, operates under a third set of considerations.

Vessels of the large-scale sector are part of the mobile, world-wide, DWFN tuna fleet. These long-range vessels change operating areas rapidly in response to catch rates, demand for raw tuna, market prices and area-specific operating costs (Indian Ocean Fishery Commission, 1985). Their major economic consideration is maximum return for minimum cost.

Vessels of the small-scale sector, not being able to easily change fishing areas, are more closely tied to local economies and in certain instances play a major role in the economies of developing Indian Ocean nations. Hafiz (1987) notes that "... [the] tuna fishery in the Maldives is one of the 'pillars' of the national economy. It provides the major source of export earnings, employment, and is directly linked with the livelihood of most island communities. [The] fisheries sector employs about 1/3 of the total labor force." The fishery also indirectly employs large numbers of workers in related occupations such as fish-curing and boat building (Anderson and Hafiz, 1987).

While a large proportion of catches by small-scale fisheries is consumed locally, in some cases a significant proportion is exported. About half of the 1985 catch of the small-scale tuna fishery in the Maldive Islands, the largest Indian Ocean small-scale tuna fishery, was exported (Hafiz, 1987).

The advent of coastal states' rights to fishery resources in their EEZ's and the development of large-scale fisheries have provided an opportunity for Indian Ocean coastal states to benefit economically from expanding tuna fisheries. An obvious way for a resource-adjacent nation to benefit from foreign fishing is to charge a fee for access to its EEZ. However, the Seychelles, the base of the major part of the large-scale purse seine fishery (the French and Spanish fleets) found that <20 percent of the foreign exchange benefits are from access fees[3]. The major part of the benefits to the Seychelles are from payment of port fees, and payment for stevedoring, food purchases, fuel, and supplies. Another way used by the Seychelles to capture some of the value of the fishery was to construct and operate a joint-venture tuna cannery with French partners. The project benefits the Seychelles by creating 250 jobs in the local economy.

A coastal nation can also benefit from resources in its EEZ by developing its own fishery. Besides benefits of fishermen's income and supply of tuna to local markets, the principal argument for developing at least some domestic capacity is to protect against the ever-present risk

[3]Michaud, P. Seychelles' response to rapid development in industrial tuna fishing. Presented to the Ninth Meeting of the IOFC Committee on the Management of Indian Ocean Tuna, Colombo, Sri Lanka, December 1986, 14 p.

of the foreign fleet's leaving the coastal state's zone for a more profitable situation. Arguments against developing catching capacity in the Seychelles in 1986 included the depressed world market for tuna, the high cost of tuna vessels and gear, and the long time needed to learn to use the technologically advanced gear[3].

Two issues will dominate the near-term future of Indian Ocean fisheries for skipjack and yellowfin tuna: 1) The degree to which tuna fisheries will develop and 2) the growing awareness that some kind of cooperative management of fisheries on commonly exploited tuna resources will probably be necessary.

Fisheries Development

Further development of the large-scale longline fishery is considered unlikely (Indian Ocean Fishery Commission, 1985). The fishery is not primarily a yellowfin fishery, but shifts its target among the various sashimi-quality fish, primarily yellowfin, bigeye, and southern bluefin tunas and billfishes. This, plus the great mobility of the fleet, suggests that future catches of yellowfin tuna will be related to resource availability as well as species-specific market demand and the economic efficacy of operating in the Indian Ocean relative to that of operating in other areas.

The large-scale purse seine fishery should continue to expand its area of operations, particularly if fishing effort increases (Indian Ocean Fishery Commission, 1985). Prospects for increased effort by the Seychelles-based fleet, and others already operating in the Indian Ocean and South Atlantic fisheries, will be related to future trends in yellowfin and skipjack tuna catch rates relative to rates in the Atlantic[3]. If exploitable resources are found in new areas in the eastern Indian Ocean, some of the current Indian Ocean-South Atlantic fleet may relocate to this area. If South Atlantic resources show greater promise, the combined fleet may favor that area. On a broader scale, the highly-mobile purse seine fleet operates in all oceans, and decisions by vessels in this fleet to fish in the Indian Ocean or elsewhere, will depend on the relative profitability of operating in the various areas. Profitability is related to catch rates, vessel support, and (at least partly) area-specific prices. Less tangible aspects, such as the desire to establish a presence in a given area, may also influence fleets' presence in the Indian Ocean. Since the target of the purse seine fleet shifts between yellowfin and skipjack tuna, future trends in catches of these species will depend on their relative abundance, market demand, and the relative economics of operating in the Indian Ocean.

Small-scale Indian Ocean tuna fisheries should continue to develop. At least one small-scale fishing nation, the Maldives, exports a significant proportion of its tuna catch, a situation likely to be repeated by other Indian Ocean nations. The Maldives and other small-scale fishing nations are increasing catches by improving existing gear or by introducing new and more efficient gear types. Postharvest processing and marketing infrastructure is gradually improving; however, significant developments in this area will probably require foreign investment and expertise. These trends will continue as many fleets modernize and expand to take advantage of the improving world market for tuna (James and Jayaprakash, 1987).

Close proximity to the resource may also provide an opportunity for coastal nations to economically enter yellowfin fisheries—such as longline fisheries in and near their EEZ's—that might be less economical for DWFN's (Indian Ocean Fishery Commission, 1984). This development is heavily dependent on developing domestic or export markets and the ability to follow the strict quality standards demanded in the sashimi market.

Prospects for a resource-adjacent Indian Ocean coastal nation wishing to benefit economically from the tuna resource without developing a fishery but by selling access rights to its EEZ, depend on how DWFN fleets perceive the economic benefit of purchasing fishing rights relative to the benefit of operating elsewhere. The key component of this economic benefit is the state of the international tuna industry and its effect on the continued operation of far-seas fisheries[3].

Fisheries Management

The need for international management of Indian Ocean tuna fisheries is increasingly discussed in area fishery management forums (Anonymous, 1987b). Coastal nations are concerned that continued expansion of both small-scale and large-scale tuna fisheries both inside and outside Indian Ocean EEZ's could reduce catches. Most often mentioned is their concern that the rapidly growing purse seine fishery will expand to areas adjacent to those used by the small-scale fisheries. They fear that this may adversely affect the availability of fish in the fishing grounds traditionally exploited by their fishermen and ultimately lead to decreased catches in small-scale fisheries (Anonymous, 1987a, 1987b).

Fishery managers' concern about possible interaction between small-scale and large-scale fisheries is only now being addressed scientifically, and little information is available on the effects of interaction among Indian Ocean fisheries. Preliminary analyses of trends in longline catches before and after the large-scale purse seine surface fishery was established suggest little interaction between fisheries on an ocean-wide basis (Suzuki, 1987). However, theoretical studies of interaction between surface and longline gears fishing on the same stock of yellowfin tuna suggest a possible advantage to total yield-per-recruit of at least yellowfin tuna from increasing longline effort while holding effort constant in small-scale and large-scale surface fisheries (Marsac and Hallier, 1987). These results cannot be applied to management at this time due to the lack of definitive stock structure information and basic population parameters.

Without formal stock-wide management of Indian Ocean tuna fisheries, the likelihood of surface fisheries limiting their activities in favor of longline fisheries is small. Current access agreements, under which more efficient (in the sense of contributing to a greater total yield-per-recruit) large-scale purse seine fisheries in effect pay rent (access fees) to less efficient local small-scale harvesters, are effectively an informal manage-

ment system that benefits longliners.

Insight into the probability of interaction between Indian Ocean tuna fisheries is provided by investigations of interaction among skipjack fisheries in the South Pacific (Kleiber et al., 1984). While the authors did not actually estimate degrees of interaction between fisheries, they did identify situations in which interaction was more likely. Applying their results to the Indian Ocean, given the current degree of fishery development, significant interaction is more likely between close-neighbor fisheries (e.g. small-scale coastal fisheries and large-scale purse seine fishery operating in an EEZ). Interaction is less likely where fisheries are widely separated.

Events directed at developing cooperative international management of Indian Ocean tuna fisheries began with the establishment of IPTP in 1982 following recommendations made by the Indo-Pacific Fisheries Commission in 1979. This was followed in 1985 by the Consultative Phase of the first Indian Ocean Marine Affairs Cooperation Conference, in which 35 states and 22 international organizations discussed formal international management (Anonymous, 1987b). The IOFC Committee for Management of Indian Ocean Tunas met in June 1988 to discuss possible long-term institutional arrangements. The Committee agreed that a new body should be established under Article XIV of the FAO constitution. In late 1988, FAO circulated a draft agreement to establish an Indian Ocean Tuna Commission. The draft was discussed at a conference in April 1989 convened to prepare a final agreement. Results of this meeting were inconclusive. However, should a final agreement be agreed on, it will then be presented to the FAO Conference for approval.

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A Demographic Profile of Participants in Two Gulf of Mexico Inshore Shrimp Fisheries and Their Response to the Texas Closure

JAMES M. NANCE, NINA GARFIELD, and J. ANTHONY PAREDES

ABSTRACT—A social study of the shrimp fisheries of Galveston Bay, Tex., and Calcasieu Lake, La., was made during the summer of 1987 to examine the impacts of the seasonal closure of the Federal waters off Texas and to understand the infrastructure and demographic processes of these two diverse fisheries. Survey instruments were administered to 159 shrimp boat captains: 89 from Galveston Bay and 70 from Calcasieu Lake. Shrimp-house owners were interviewed in each region as well.

The results suggest that the inshore fisheries (i.e., shrimpers and shrimp houses) are distinct from the offshore fisheries. The infrastructure of the two inshore fisheries examined differ in that the market distribution of shrimp from Galveston Bay was more diffuse than from Calcasieu Lake. Much more of the shrimp harvested from Galveston Bay was channelled into the surrounding community than from Calcasieu Lake.

The distribution of age, years as a commercial fisherman, and family involvement in fishing suggest that participation in Calcasieu Lake's and Galveston Bay's inshore fisheries have expanded concurrent with declining economies. While overall the Texas closure had little impact on either of the inshore fisheries, the Galveston Bay shrimpers experienced more of a direct impact on their livelihood than Calcasieu Lake shrimpers.

Introduction

The life cycle of Gulf of Mexico shrimp ranges from the inland coastal estuaries into the deeper waters of the Gulf. Consequently, shrimp are harvested by both inshore and offshore shrimpers. These two user groups harvest the same resource, yet are distinct with respect to their fishing locations, the size and value of shrimp they target, and the government management regimes that regulate them. Concerns regarding equitable allocation of the resource have historically influenced management decisions pertaining to regulation of inshore and offshore shrimp seasons. However, it has been difficult to make such allocative decisions and monitor the effectiveness of policies when little is known about the social characteristics and economic needs of inshore fishermen.

In 1981, the Gulf of Mexico Fisheries Management Council (GMFMC) implemented a policy known as the Texas closure (Gulf of Mexico Fishery Management Council, 1980; Leary, 1985). This closure of the exclusive economic zone (EEZ) off the Texas coast, from about 1 June through 15 July, is concurrent with the closure of state waters which has been in effect since 1959 (Texas Shrimp Conservation Act, 1959). The Federal closure permitted, for the first time, a total closure of the fishery for brown shrimp, *Penaeus aztecus*, fishery from the coastline to 200 n.mi. off the Texas coast. The objectives of the closure were twofold: 1) To increase the value of the offshore shrimp fishery by delaying the harvest of shrimp until they reached an optimum size and 2) to reduce the wasteful discard of undersized shrimp by eliminating count restrictions (Jones et al., 1982; Klima et al., 1982; Matthews, 1982; Nichols, 1982; Poffenberger, 1982). For the past eight years (1981-88) the GMFMC has agreed to continue the Texas closure. However, the 1986 through 1988 closures were each reduced from 200 miles to only 15 miles off the Texas coast. It was determined by the GMFMC that this reduced closure would provide sufficient protection for the small brown shrimp while permitting the harvest of larger brown shrimp in deeper waters.

Since its inception, the biological and economic impacts of the Texas closure on the offshore shrimp fishery have been monitored (Jones and Zweifel, 1982; Klima et al., 1982, 1983, 1984, 1985, 1986, 1987; Nance et al., 1988; Poffenberger, 1982). The social impacts of the Texas closure on the offshore fisherman began to be studied in 1986 (Klima et al., 1987; Nance et al., 1988), but to date no attempt has been made to study the impacts of the Texas closure on inshore shrimpers. Consequently, the full effects of the Texas closure are unknown. Further, little is known about the importance of the inshore shrimp fisheries to the local economies, making it difficult for the GMFMC to make informed decisions regarding equitable allocations of the shrimp resource.

The goals of this report are to 1) identify the marketing and distribution channels toward which the inshore fisheries are oriented, 2) describe the demographic

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profiles of two Gulf of Mexico inshore shrimp fisheries, and 3) examine the impacts of the Texas closure on inshore shrimpers near the closure area by assessing their opinions and perceptions of how they have been affected by this policy.

Galveston Bay, Tex., and Calcasieu Lake, La., were the two areas chosen for study of the inshore shrimp fisheries. These areas were chosen for three reasons: 1) They are located in neighboring states and are near each other, separated by about 75 miles, 2) the fisheries were anticipated to differ socially and industrially since they target different sizes of shrimp, and 3) the bays represent very different natural and human environments reflecting some measure of the considerable socioeconomic diversity that characterizes the U.S. Gulf of Mexico coastal communities.

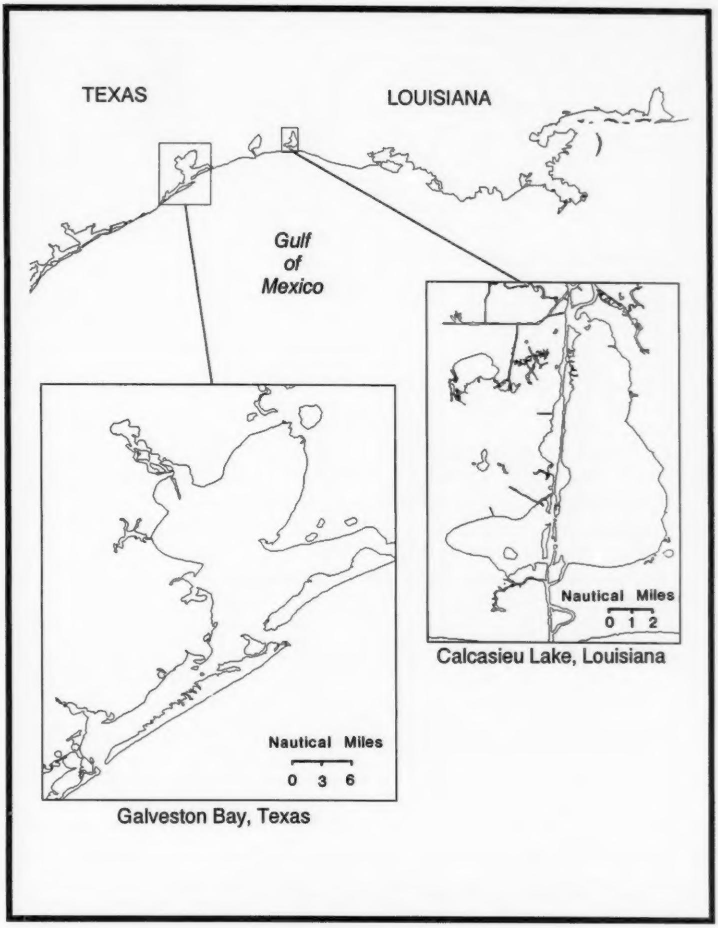

Figure 1.—Location of inshore fishery samplings sites.

The Study Areas

Galveston Bay

Galveston Bay is an irregularly shaped estuary 17 miles long by 3 miles wide at its most distant points (Fig. 1). Its depth ranges from 2 to 44 feet, exclusive of navigation channels. The Bay is heavily used for shipping, recreational fishing, and boating, as well as for the commercial harvest of shrimp, oysters, and crabs. It is bordered to the southeast and northwest by the cities of Galveston and Houston, respectively, which are rapidly becoming linked by the expanding communities on the western side of the Bay. Little development has occurred on the east side of the Bay which is still characterized by rural communities. Overall, the population in the three counties surrounding the Bay is about 3.0 million (U.S. Dep. Commer., Bur. Census data, 1986).

While the eastern side of Galveston Bay is dominated by farms (rice and soybean) and wildlife reserves, the other areas of the Bay are industrially developed. Petrochemical, manufacturing, and tourist industries are the dominant economic entities in the region. The significance of Galveston Bay to the local economy is apparent in that 45 percent of the city of Galveston's economy is derived from waterborne commerce (Galveston Chamber of Commerce, 1987). Economic indicators (unemployment rates, industrial plant closings, export rates from deepwater ports, house foreclosures, etc.) suggest that the economics of the counties around Galveston Bay suffered a sharp decline beginning in about 1984 (Galveston Chamber of Commerce, 1987; Houston Chamber of Commerce, 1988).

The communities bordering the east side of Galveston Bay are characterized by ethnic uniformity. Caucasians are the dominant group present. In contrast, the more urbanized areas around the Bay are ethnically diverse. Caucasians are still a prominent group, but Blacks and Hispanics are also found in considerable numbers. Southeast Asians (predominantly Vietnamese), Hispanics, and Italians comprise the majority of the recent immigrants residing in these communities.

The participants in the inshore shrimp fishery represent both the long-time residents and the growing immigrant presence in the bayside communities. Much of the change that has occurred

within the inshore fishery in recent years can be attributed to the expanding southeast Asian population. According to data from Texas Parks and Wildlife license files, the number of Vietnamese-owned boats in the counties around Galveston Bay has increased from 154 in 1981, to 437 in 1986. This represents a 280 percent increase, despite a corresponding 35 percent decrease in the number of licensed boats from 2,664 to 1,795 during these same years. Although these figures include both offshore and inshore boats, the majority of these Vietnamese boats participate in the inshore fishery since they possess one of the inshore license types.

Shrimping in Galveston Bay is done by trawling. Most of the boats in the inshore fishery are of a medium size (21-40 feet), while large boats (>40 feet) represent the least frequently used vessel size (Fig. 2). The differences between the number of vessels within each of the three vessel size categories are highly significant ($P = 0.01$).

Texas commercial shrimpers may hold any combination of three licenses: Bay, bait, or Gulf. The bay and bait licenses represent the inshore fishery, which is confined to harvesting shrimp in the nonnursery estuaries of Texas. The Gulf license is required in order to land shrimp caught in Gulf of Mexico waters. Both the inshore and offshore fisheries within the territorial sea are managed by Texas Parks and Wildlife. The Texas management objective for the commercial shrimp fisheries is to maximize the harvest of medium-to-large shrimp for sales to retail outlets, stores, restaurants, and for home consumption (Christmas and Etzold, 1977; Gulf of Mexico Fishery Management Council, 1980).

The bait shrimp fishery is a year-round fishery catering to the bait needs of recreational fishermen. Those shrimping with a bait license may harvest a maximum daily catch of 200 pounds, half of which must be kept alive, except during the period from 16 August to 15 November. Only one main trawl, with a width of 34 feet between the doors, may be used from the boat. Mesh size of the net may not be less than 6½ inches in length between the two most widely separated

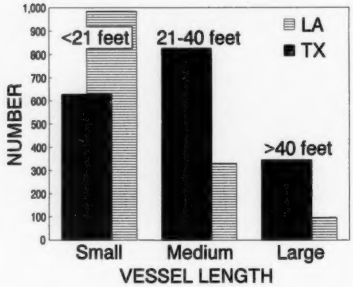

Figure 2.—Number of vessels in each size category for the two inshore sites.

knots in any consecutive series of five stretched meshes (Texas Parks and Wildlife Department, 1987). Unlike the commercial bay fishery (described next), the bait fishery is not restricted by either time of day or seasonal closure; a modification implemented when the Texas closure went into effect in 1981.

The management of the commercial bay fishery is regulated with seasonal closures and gear restrictions (Texas Parks and Wildlife Department, 1987). During the spring season, from 15 May to 15 July, shrimpers harvesting with a bay license may trawl with one main net no wider than 34 feet between doors. In addition, mesh size may not be less than 6½ inches in length between the two most widely separated knots in any consecutive series of five stretched meshes. Fishermen are limited to a daily catch of 300 pounds and permitted to shrimp only between sunrise and sunset (daylight). These restrictions are to ensure that a sufficient amount of brown shrimp migrate offshore. During the first part of the fall season, from 15 August to 15 October when inshore shrimpers mostly harvest white shrimp, *Penaeus setiferus*, bay shrimpers may harvest an unlimited amount of shrimp, however they are restricted by a size limit of 50 heads-on shrimp to the pound. From 15 October to 15 December, no size limit is imposed on shrimp harvested in the bays. During the entire fall season, from 15 August to 15 December, shrimpers are permitted to use one main net with a maximum total width, including the doors, of 95 feet, and a mesh size not less than 8¾ inches between the two most widely separated knots in any consecutive series of five stretched meshes. These regulations enable the inshore shrimpers to target the larger and more valuable white shrimp which remain predominantly in the bays and nearshore in the Gulf. Thus, shrimping with a bay license is prohibited during the 1-month closure between the spring and fall seasons, and the 5-month closure between the fall and spring seasons. Overall, the regulations allocate the more highly migratory brown shrimp primarily to the offshore shrimpers, and the less migratory white shrimp to the inshore shrimpers. Both management regimes target large valuable shrimp.

Many shrimpers hold both bay and bait licenses to take advantage of the more lenient restrictions of the bait license during the seasonal closure, as well as the larger poundage allotment afforded by the bay license during nonclosure periods. This is evidenced by the increase in the percentage of shrimpers holding a bait license in conjunction with a Gulf and/or bay license from 28 percent in 1981 to 41 percent in 1987 (Texas Parks and Wildlife Department license files, 1981 and 1987). This increase in participation in the bait fishery has occurred despite a decrease in landings by Galveston Bay anglers (Osburn and Ferguson, 1985).

Calcasieu Lake

Calcasieu Lake is smaller than Galveston Bay, extending 2 miles wide and 3 miles long at its most distant points (Fig. 1). Calcasieu Lake is connected to the Gulf by a narrow channel known as Cameron Pass which is bordered by the fishing port of Cameron, La. Shrimp houses serving offshore vessels are, for the most part, located along the banks of Cameron Pass. The upper portion of Calcasieu Lake is characterized by an extensive network of bayous with marshlands providing nursery areas for juvenile shrimp. Shrimp houses and boats utilized in the inshore fishery are located along these channels in the upper portion of the bay and in West Cove.

Like Galveston Bay, Calcasieu Lake is heavily used for shipping. The Port of

Lake Charles is the largest exporter of rice in the United States (Lake Charles Chamber of Commerce, 1987), and the ship channel from the Gulf of Mexico to Lake Charles runs through Calcasieu Lake. Despite this similarity with Galveston Bay, however, the economy surrounding Calcasieu Lake is less diverse with respect to employment opportunities. In contrast to Galveston Bay, Calcasieu Lake is surrounded completely by Sabine National Wildlife Refuge and rural communities heavily dependent on farming (rice, soybeans), fishing (redfish, oysters, speckled trout, menhaden, crabs), and the petrochemical industry. Currently, 25 percent of Cameron's civilian labor force is employed in the fishing industry (Lake Charles Chamber of Commerce, 1987). Expansion of the inshore fishery has seemed to parallel the decline in the petrochemical industry due to the lack of industrial diversity in the region (Petty, 1986). Overall, the population in the two parishes surrounding the Lake is only about 27,500 (U.S. Dep. Commer., Bur. Census data, 1986).

The populations in these rural areas are much more ethnically homogeneous than those surrounding Galveston Bay. According to the most recent census, only 0.6 percent of the population is made up of ethnic minorities other than Blacks (U.S. Dep. Commer., Bur. Census data, 1986). Calcasieu Lake's inshore fishery reflects the same ethnic homogeneity characterizing the surrounding communities in that most of the inshore shrimpers are of Caucasian descent. This lack of ethnic diversity is a result of local unity and an unwillingness by the local shrimpers to allow newcomers, especially minorities, into the fishery or even to settle in the area.

Unlike the Galveston Bay fishery, Louisiana's fishery targets small shrimp destined for canneries (Pawlyk and Roberts, 1986). Of the 37,000 commercial shrimp licenses issued in 1986, only about 3,000 were issued to offshore vessels. The typical operation in Louisiana's shrimp fishery is a single-family business dominated by small vessels (Petty, 1986). The inshore shrimp fishery of Calcasieu Lake reflects this description with the majority of the inshore boats being less than 21 feet (Fig. 2). As in Galveston Bay's fishery, the differences between the numbers of boats within each of the three size categories is highly significant ($P<0.01$).

The inshore shrimp fishery in Louisiana is regulated by seasonal closures that roughly coincide with those implemented in Texas (Louisiana Sea Grant, 1987). Yet, there are four fundamental ways that Louisiana's management of the inshore shrimp fishery differs from that of Texas. First, Louisiana's closure between the spring and fall season is complete; without a developed tourist industry around Calcasieu Lake there is no local demand for bait shrimp. Second, size restrictions are lenient. Shrimpers are permitted to harvest heads-on shrimp greater than 100-count to the pound. Third, Calcasieu Lake inshore shrimpers may catch an unlimited amount of shrimp day and night, spring and fall. Fourth, Louisiana shrimpers are licensed according to the type of gear they use which varies depending on daytime or nighttime usage.

Inshore shrimpers purchase trawl licenses for day shrimping and butterfly licenses for night shrimping. Trawling occurs in the open portion of Calcasieu Lake, whereas the use of butterfly nets is limited to the narrow channels leading to and extending from the bay. Butterfly nets are attached to square metal frames suspended from either side of a boat or stationary structure, known as a barge or pontoon. The frames range in size from 12×8 feet to 12×16 feet on mobile structures. On stationary structures single nets 22×22 feet or double nets 12×12 feet are permitted. The nets are suspended just below the surface of the water to trap shrimp carried by the tides. Since success with butterfly nets depends on the strength of the tides, the intensity of night shrimping fluctuates with the lunar cycle. Fishing effort with butterfly nets, therefore, peaks from about 3 days before to about 3 days following either a new or full moon phase in the lunar cycle. Many shrimpers hold both a saltwater trawl and butterfly license enabling them to participate in both the daytime and nighttime fisheries. Louisiana prohibits the use of butterfly nets by nonresidents who are not permitted to use this type of gear in their home states (Edwards, 1986). Thus, Texas shrimpers are prohibited from this sector of Louisiana's inshore shrimp fishery since butterfly nets are outlawed in Texas.

Materials and Methods

An interview survey was conducted with inshore shrimp boat captains in both Galveston Bay and Calcasieu Lake in the summer of 1987. License lists of captains from 1986 were supplied by the Texas Parks and Wildlife Department and the Louisiana Department of Wildlife and Fisheries. From these lists, captains were selected using a Fortran[1] pseudorandom numbers program so that all licenses had an equal probability of being selected. Three samples, containing 75 names each, were generated for each region to correspond with the three vessel size categories: Boats <21 feet, boats 21-40 feet long, and boats >40 feet. These size categories were chosen on the assumption that the entailed fundamental occupational differences with respect to the kinds of fishing activities functionally related to differences in vessel size. It was believed, for example, that as vessel size increases, there would be a corresponding increase in the number of shrimpers who harvest both offshore and inshore and who were economically dependent on shrimping. Results from the survey validate this assumption. By grouping shrimpers in this way it was possible to examine the differential impacts of the Texas closure on shrimpers with varying geographic, occupational, and social characteristics.

When phone numbers could be obtained, interviews were conducted with captains by telephone. A questionnaire was mailed to those names with unlisted phone numbers or without telephones. To supplement this randomized survey effort, interviews were conducted at docks around the perimeter of each bay. This additional effort ensured that 1) enough interviews for analysis were completed, in the limited available time (3 months),

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 1.—Interview results from captains randomly selected to participate in the study.

Method	Galveston Bay	Calcasieu Lake
Phone interview		
Interviewed	37	11
Refused	(14)	(4)
No longer shrimping	(37)	(14)
Total	88	29
Mailed interview		
Wrong address	(17)	(85)
Received back	8	7
Total	94	196
Other problems		
Non-English speaking Vietnamese	(43)	(0)
Total interviewed	45	18

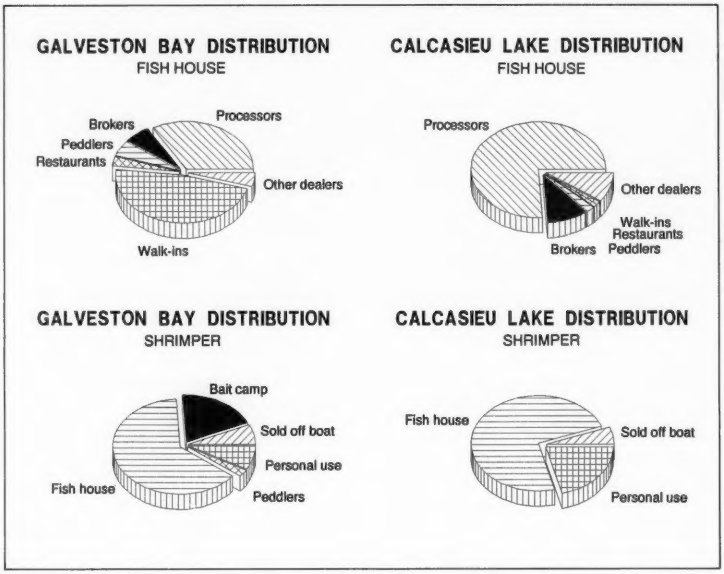

Figure 3.—Market distribution of shrimp catch by shrimpers and local processors at each site.

2) that all regions in each bay were represented in the survey, and 3) that individuals with little or no knowledge of the English language, i.e., Vietnamese, Italians, and Hispanics were represented. Interpreters were used to interview such members of these ethnic populations. Dockside interviews also were beneficial in that they allowed the researchers to probe and clarify responses.

The survey was supplemented with participant observation and in-depth interviewing. A mixed sample of individuals were selected for in-depth interviews including older and younger shrimpers, fish-house owners, newcomers and long-time participants in the industry, owners of fishing supply and net shops, and bank loan officers.

Collected data were entered into a database management program on the computer. Data were summarized into various groups as needed for analysis. Group comparisons and percentages of various group components were the usual extent of the analysis. Statistical differences between entities were determined with Chi-square procedures (Sokal and Rohlf, 1981).

Results

A total of 159 interviews were completed during the study period, with 89 from the Galveston Bay area and 70 from the Calcasieu Lake site. Table 1 lists the results from the random interview portion of the survey. Supplemental dockside interviews accounted for 50-75 percent of the total interviews at each site, with 44 conducted around Galveston Bay and 52 from Calcasieu Lake.

Market Distribution Patterns of Shrimp

The market distribution channels of shrimp from the inshore fisheries of Galveston Bay and Calcasieu Lake are illustrated in Figure 3. Examination of the results indicate that while most of the shrimp were destined for shrimp houses, a greater proportion of shrimp from Calcasieu Lake (73 percent) were sold to shrimp houses than from Galveston Bay (63 percent). In Calcasieu Lake, most of the shrimp not destined for shrimp houses were used for personal consumption (21 percent), with the rest sold directly off the boat (6 percent). In Galveston Bay, the remaining shrimp not sold to shrimp houses (37 percent) were distributed either directly from boats to tourists (7 percent) or peddlers (3 percent), used for personal consumption (8 percent), or sold to bait camps (19 percent).

The Calcasieu Lake shrimp houses relied heavily on processors as markets for their shrimp. About 76 percent of the shrimp distributed by Calcasieu Lake's inshore shrimp houses were destined for processors. Brokers and other dealers were the recipients of the remaining 24 percent of the shrimp distributed by Calcasieu Lake inshore shrimp houses. Galveston Bay's inshore shrimp houses, however, relied more heavily on local markets for shrimp distribution with only 33 percent of the shrimp distributed to processors. Of the remaining 67 percent, about 47 percent was sold to individual customers, 7 percent to brokers, 5 percent to peddlers, 5 percent to other dealers, and 3 percent directly to stores and restaurants.

The role of shrimp houses in the inshore fisheries was examined by assessing 1) the extent of integration of shrimp houses with other sectors of the local industry (i.e., retail and harvesting sectors), 2) the degree of centralization among shrimp houses, and 3) the dependency of shrimp houses servicing inshore boats on shrimp harvested by this fishery. Due to the relatively small size of the inshore fishery in Calcasieu Lake compared with Galveston Bay, owners of all five of the shrimp houses that service the inshore fishery were able to be inter-

viewed. Each shrimp house was heavily integrated with other local sectors of the industry, including harvesting (owning boats) and retail (owning seafood markets). Calcasieu Lake shrimp houses depended largely (89 percent) upon shrimp harvested from local inshore waters.

Of the 21 shrimp house owners interviewed around Galveston Bay, 17 (81 percent) were integrated with another aspect of the local fishery by owning commercial shrimp boats and/or retail seafood markets; 13 (77 percent) owned boats, 12 (71 percent) owned markets, and 8 (47 percent) owned both boats and markets. Four (19 percent) of the shrimp-house owners interviewed reported owning more than one shrimp house. As in Calcasieu Lake, shrimp houses in Galveston Bay that serviced inshore boats seemed highly dependent for their product from local shrimp harvest. During the spring season 83 percent of shrimp passing through these shrimp houses were reported to have come from Galveston Bay, compared with 97 percent during the fall season.

Demographic Profile

The demographic profiles of the inshore fisheries to be presented include certain occupational and personal characteristics of the surveyed populations. The occupational characteristics examined included areas fished and economic dependency on shrimping. Personal information describing the shrimpers included age, years as commercial fishermen, family history in the fishing industry, and employment histories.

Occupational Characteristics

Harvesting areas of inshore shrimpers were examined in both the inshore and offshore locations (Fig. 4). The data indicate that as vessel size increased, there was greater participation of inshore shrimpers in the offshore fishery. This participation was greater in Calcasieu Lake region than in Galveston Bay among small (<21 feet) and large boats (>40 feet), and was approximately equal among medium sized boats (21-40 feet). The most notable difference between the two fisheries in these respects was that 80 percent of the larger boats from Calcasieu Lake fished both inshore and offshore while only 39 percent of Galveston Bay large vessels worked both inshore and offshore.

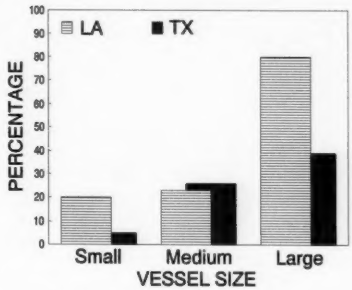

Figure 4.—Percentage of sampled vessels participating in both the inshore and offshore fisheries grouped by vessel size.

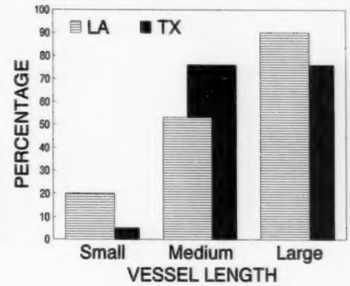

Figure 5.—Percentage of captains, grouped by vessel size, that rely on shrimping for total income.

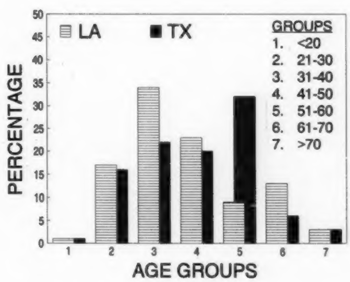

Figure 6.—Age distribution of captains from the two inshore sites.

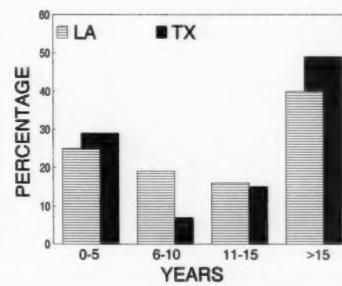

Figure 7.—Distribution of captains, categorized by length of time of their involvement as commercial shrimpers.

Trends by vessel size among inshore shrimpers regarding economic dependence on shrimping was next examined (Fig. 5). Overall, 54 percent of the Calcasieu Lake shrimpers and 62 percent of the Galveston Bay shrimpers reported to be fully dependent on these occupations for monetary support. In both populations there was an increased number of shrimpers fully dependent upon their occupation for income as vessel size increased. Among the small and large vessels, there were proportionally more Calcasieu Lake shrimpers fully dependent on shrimping than Galveston Bay shrimpers. However, few small boats in either population relied totally on shrimping for their income. The opposite was true for medium sized boats, in which proportionally more Galveston Bay shrimpers were economically dependent on shrimping than among Calcasieu Lake's medium sized boat operators.

Personal Characteristics

The age distribution of inshore shrimpers in both regions was examined (Fig. 6). Within 10-year cohorts, the highest proportion of shrimpers was 31–40 years of age in Calcasieu Lake, whereas the greatest number of Galveston shrimpers was 51–60 years of age. The median ages of the Calcasieu Lake and Galveston Bay shrimpers were 39.4 and 47, respectively.

The number of years that shrimpers in each population had been commercial shrimpers was next investigated (Fig. 7). These data allowed estimation of when periods of growth (people entering into

the shrimping profession) took place. While the greatest period of growth in each fishery seemed to have occurred more than 15 years ago, there was some indication that a minor growth period had occurred within the last 5 years in Galveston Bay's fishery, and within the last 10 years in the inshore fishery of Calcasieu Lake.

There was some indication that the captains who had been in the fishery the longest time operated the larger boats (Fig. 8). The means, however, were not significantly different. No information was available from the captains of small boats in Galveston Bay because questions related to this aspect were added to the survey after most of this population had already been interviewed.

If captains reported having a parent or grandparent who were commercial fishermen, they were coded as coming from a family involved in fishing. The results indicate that 62 (70 percent) of the shrimpers in Galveston Bay came from fishing families compared to 29 (41 percent) of the Calcasieu Lake shrimpers (Fig. 9). The differences in frequencies between these two populations were statistically significant ($P=0.01$). Of those shrimpers who came from fishing families, most had been in the fishery >10 years. Among the Galveston Bay sample, 80 percent of shrimpers with a history of family involvement in shrimping entered the fishery >10 years ago. Among the Calcasieu Lake sample, 67 percent with a family history in shrimping had entered the fishery >10 years ago.

Employment histories from both were grouped by job skills (Table 2). The Calcasieu Lake shrimpers were characterized by less diversity in their occupational histories (fewer job types) than Galveston Bay shrimpers. Results indicate that among Calcasieu Lake shrimpers, 70 percent had histories dominated by manual labor (construction worker, welder, carpenter, mechanic, oil field worker, pipefitter, cementer, tool picker, net maker, repairman, etc.). Of the remaining individuals, 7 percent were previously employed in service oriented occupations (truck driver, security guard, police officer, armed forces,

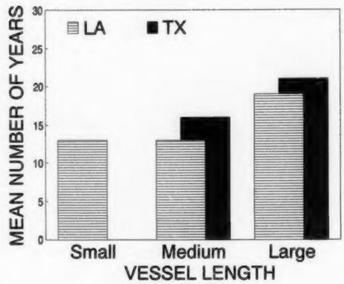

Figure 8.—Distribution of captains, categorized by both mean length of time of their involvement as commercial shrimpers and size of vessel they operate.

preacher, salesman, etc.), 9 percent were small business owners or managers (grocery store, boat retail, fish house, etc.), 2 percent were in technical fields (laboratory technician), and 9 percent claimed they had no other skills. No response to this part of the questionnaire was received from 3 percent of the interviewed population.

The Galveston Bay shrimpers had a more diverse range of occupational histories compared to Calcasieu Lake shrimpers (Table 2). Like the Calcasieu Lake population, most Galveston Bay shrimpers (48 percent), were previously employed in skilled manual labor jobs. Of the remaining, 9 percent were employed in service occupations, 9 percent were owners or managers of small businesses, 8 percent were in technical fields, 4 percent were professional (research engineer and school administrator), 9 percent were in unskilled labor (mushroom picker, dish washer, etc.), 10 percent had no other skills, and 3 percent gave no response.

Texas Closure

An effort was made to solicit opinions and perceived impacts of the Texas closure from inshore shrimpers. Among the Calcasieu Lake shrimpers, 75 percent expressed no opinion regarding the Texas closure, and most of the remaining shrimpers (20 percent) disapproved of the closure (Fig. 10). The Galveston Bay

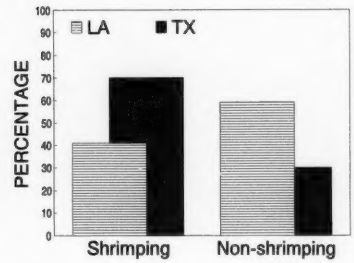

Figure 9.—Percentage of interviewed captains categorized by having either shrimping or nonshrimping family background.

Table 2.—Distribution of job skills by region.

Skills	Galveston Bay	Calcasieu Lake
No other skills	9 (10%)	6 (9%)
Unskilled labor	8 (9%)	0 (0%)
Skilled manual labor	43 (48%)	49 (70%)
Service occupation	8 (9%)	5 (7%)
Small bus. owner/mgr.	8 (9%)	6 (9%)
Technician	7 (8%)	2 (2%)
Professional	4 (4%)	0 (0%)
No response	2 (2%)	2 (3%)

shrimpers were more opinionated, but even so only 45 percent expressed an opinion regarding the Texas closure. The opinions were almost equally divided between favoring (24 percent) and disapproving (20 percent) of the closure. The comments from shrimpers revealed that the impact of the Texas closure on inshore shrimpers increased with vessel size (Fig. 11). Proportionally more captains of the medium sized boats in Galveston Bay (20 percent) were personally affected by the closure than in Calcasieu Lake (10 percent). Conversely, proportionally more captains of the large Calcasieu Lake boats (32 percent) were impacted by the closure than captains of the corresponding size category of Galveston Bay boats (28 percent).

Comments from most of the Calcasieu Lake shrimpers with an expressed opinion indicated that their work activities were affected by the displacement of Texas boats into Louisiana as a result of

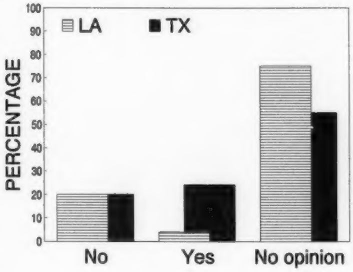

Figure 10.—Percentage of captains against (NO), in favor of (YES), or with no opinion about the closure of Federal waters off Texas.

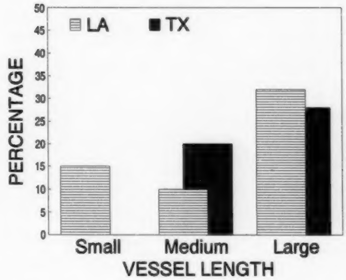

Figure 11.—Percentage of captains, categorized by vessel size, who felt the Texas closure regulations impacted their lives.

shrimp house were primarily used for personal consumption.

In contrast, much of the shrimp profits in the Galveston Bay fishery remained within this greatly urbanized community since most shrimp were distributed to customers by local shrimp houses and were not sold to processors. Thus, the inshore and offshore fisheries in the area are more loosely connected at the processor level and their infrastructures not as intertwined as in Calcasieu Lake. The majority of the shrimp bypassing the shrimp houses was distributed to recreational fishermen through bait camps.

An understanding of distribution and marketing channels is important in determining the overall value of the shrimp fishery to local economies. To date, when economists determine the value of the shrimp fishery to the economy in general, they do not distinguish between the differences that exist between each fishery. Consequently, it is assumed that shrimp is exchanged only once within the community and a value to the fishery is accordingly estimated[2]. Thus, in situations where shrimp is exchanged more often within a community, the value of the fishery is likely to be underestimated. The results of this study suggest that shrimp is exchanged more often within the communities surrounding Galveston Bay than Calcasieu Lake.

This difference between Calcasieu Lake and Galveston Bay, with regard to marketing channels, or the number of times a particular shrimp "changes hands" within a single localized area while on its way from shrimper to consumer, is a function of the size of the population base and industrial complexes surrounding the area. In the Calcasieu Lake situation, like most rural coastal areas, each shrimper is extremely dependent on the income received from selling shrimp to the shrimp house, since few other jobs are available in the surrounding community. Yet, because of the weak industrial complex and small population base in the area (< 1 percent of the population found around Galveston Bay), the

the closure. Crowded fishing grounds, reduced catches, and reduction in both supplies and dock space available to local shrimpers were cited by Louisiana shrimpers as consequences of the closure-induced displacement of Texas vessels. Some of the captains of large boats remarked that reduction in catch negatively impacted their incomes. However, one captain of a large boat commented that during the Texas closure there was a resultant increase in the price of shrimp offered in Louisiana, thus having a positive impact on his income.

The captains of large Texas boats reported to have experienced personal impacts of the Texas closure of three types: 1) Traveling to Louisiana to shrimp because it was too dangerous and uneconomical to travel farther out than 15 miles (the extent of the Texas closure during the 1986-88 seasons), 2) shrimping only in Galveston Bay which was already overcrowded and, consequently, they experienced a reduction in income, and 3) the drop in the price of shrimp following the opening of the closure. Similarly, the captains of medium sized Galveston boats complained of overcrowding in the bay during the closure, and of a decrease in the price of shrimp following the closure.

Discussion and Conclusions

This study has attempted to highlight some similarities and differences between participants in the inshore shrimp fisheries from the Texas-Louisiana boundary area along the Gulf Coast. Comparisons were made in such areas as marketing infrastructure, demographic profiles, and impacts of the Texas closure.

The results of the survey suggest that the inshore fisheries in each region were distinct from the offshore fisheries. This was evidenced by 1) the small degree of territorial overlap of offshore and inshore fisheries among small and medium sized boats, the two size categories comprising the majority of the inshore fisheries, 2) the dependence of shrimp houses serving inshore boats on the shrimp harvested from inside waters, and 3) the high degree of local shrimp house integration within each of the inshore fisheries examined.

Regional differences existed with respect to how shrimp was marketed. Most of the shrimp from the Calcasieu Lake fishery was sold to shrimp houses, which in turn sold them to both local and nonlocal processors. Thus, the vertical marketing integration within this fishery existed largely between the shrimp houses and processing plants. This marketing practice not only channels shrimp profits out of this rural community, but also makes the inshore fishery economically tied to the infrastructure of the offshore fishery since shrimp from the offshore fishery are going to these same processing plants. The shrimp that bypassed the

[2]M. Wilson, Research Assistant, Tex. A&M Univ., Dep. Wildl. Fish., Coll. Sta., Tex. Personal commun., 1988.

shrimp house sells the shrimp to nonlocal buyers and processors and the profits after that point are distributed outside of the local economy. In the Galveston Bay situation, like most urbanized coastal areas, each shrimper feels dependent on shrimping for his income, but since other jobs are available in the community, he could still remain employed in the area even if he decided to quit his shrimp harvesting profession. With the large population base and industrial complexity of the area, the shrimp house is able to sell to many local markets, which tends to multiply the initial profits and keep them within the local economy.

The demographic profiles of the populations indicate that different social processes are occurring within the two fisheries. First, data on number of years each captain has been active in the fishery suggest a gradual increase in Calcasieu Lake's fishery within the last 10 years, while much of the recent growth in Galveston Bay's fishery has occurred only within the last 5 years. Expansion in Galveston Bay's fishery can largely be attributed to influx from the growing Asian immigrant populations in the area, while the increase in the Calcasieu Lake fishery coincides with local economic declines from oil production (Petty, 1986). Second, more of the Galveston Bay shrimpers came from fishing families than Calcasieu Lake shrimpers. In both populations, family involvement in fishing was less evident among the newer participants than among the shrimpers with more experience. This, coupled with the fact that Calcasieu Lake shrimpers were generally younger than Galveston Bay shrimpers, suggests that the Calcasieu Lake fishery is a newer fishery than Galveston Bay's fishery. It also reflects the importance of the inshore fishery in rural areas as an employment safety net during times of economic hardship.

More of the Galveston Bay inshore fishermen reported impacts from the Texas closure than did shrimpers from the fishery in Calcasieu Lake. The size of Galveston Bay can support many of the larger offshore boats displaced by the closure. Consequently, the areas in which the inshore shrimpers harvest became increasingly crowded during the closure, resulting in a reduction of income. This impact of the closure was reported by about 30 percent of the Galveston shrimpers interviewed. Only 20 percent of the Calcasieu Lake interviewees reported direct personal impacts of the Texas closure. Operators of large boats most frequently reported impacts among the Calcasieu Lake sample. Crowded fishing grounds and limited dock space and supplies were cited as the major impacts. The depth and size of Calcasieu Lake, coupled with prohibition of Texas boats from using butterfly nets limits the opportunities of larger Texas boats from harvesting in this body of water. Therefore, it is not surprising that it was the larger Calcasieu boats, that harvest both offshore and inshore, which reported the greatest impact. It seems likely that what was described by Calcasieu Lake shrimpers was, in fact, the offshore impacts of the Texas closure rather than on the inshore fishery. Thus, only vessels fishing in offshore waters would feel the impact and report it. Comments from captains of large inshore vessels about the impacts of the closure are similar to those given by offshore shrimp vessel captains from the same area (Klima et al., 1987; Nance et al., 1988).

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Understanding the Market for Charter and Headboat Fishing Services

ROBERT B. DITTON, DUANE A. GILL, and CAROL L. MacGREGOR

Introduction

This paper summarizes research findings published during 1974-86 regarding charter and headboat[1] anglers to assist operators in locating potential markets for their services. The goal of the literature review was to reach some generalizations regarding charter and headboat fishing anglers' sociodemographics, motivations, and attitudes. Information beyond the customer's name and address is vital if operators want to plan a successful marketing strategy for their services, provide a better experience for current customers, and expand their clientele (Dittrich, 1974; DeYoung, 1986).

Much of the literature on the charter/headboat fishing industry has focused on the economic aspects of maintaining a charter business, catch records and statistics, or operator characteristics and demographics. Most studies used personal interviews with operators to investigate financial and business aspects and obtain catch/effort data to describe a state or regional charter/headboat industry. These studies provide pertinent information for operators considering initial or alternative business investment decisions. They also have been used to estimate the number of clients served, the economic impact on coastal communities, and the impact of recreational fishing on fish stocks. In many of the studies, the operators' perceptions of customers' motivations and expectations is provided. However, more specific information regarding angler expenditures and sociodemographics has been collected through direct mail questionnaires and through on-site interviews of customers. Studies of anglers have usually been preceded by studies of operators which have provided access to customer lists. This paper compares and contrasts the results of charter and headboat angler studies.

Table 1 provides an overview of studies of charter and headboat anglers conducted in the last 15 years. This is an exhaustive listing of published papers and published theses and administrative reports regarding charter and headboat anglers completed between 1974 and 1986. Publications since 1986 were not considered. It is difficult to compare study results since surveys varied in sampling procedures, question format, and response categories. These inconsistencies often frustrated efforts to generalize across studies. Also, there are inconsistencies in the definition of a charter boat and headboat throughout the studies. For purposes of this review, results are presented according to the terminology used in each respective study.

Four categories of information on charter/headboat anglers are discussed in the literature review. Not all studies covered the variables of concern in this paper; therefore, tables only include the applicable studies which covered:

1) Social and demographic characteristics, including gender, age, income, level of fishing skill, group composition, and residence location;

[1]Commercial passenger fishing vessels include both charter and headboats. Charter boats commonly carry six or less passengers in addition to crew whereas headboats usually carry more than six passengers. Also, there is an important distinction in the business transaction involved; for charter boats a single group of anglers purchase the services of boat and crew for the day, whereas with headboats, groups and individuals pay a per-person fee to go fishing. Base fees for charterboats tend to be much higher than the per-person fees for headboats. In response to regional preferences, the term "partyboat" is used as a synonym for headboat.

ABSTRACT—Published and unpublished research findings regarding charter and headboat fishing customers from 11 studies were reviewed to provide a marketing data base for operators and to guide further research efforts. Generally, charter/headboat fishing is a male-oriented activity. Customers were between 30 and 55 years of age. Although both groups of anglers considered themselves to be experienced, charterboat anglers had fished for more years. Charter anglers fished more often with their families and headboat anglers more often with their friends. Charterboat anglers reported higher incomes than headboat anglers. Relaxation, having fun, and escaping from daily pressures were generally more important to both groups of anglers than motives relative to catching fish. Most anglers indicated that the skills and performance of the captain and crew contributed heavily to the overall evaluation of their fishing experience. Anglers were more heavily influenced to choose a particular captain or boat by informal advertising methods (i.e., word-of-mouth recommendations, reputation, and visits to the marina) than formal methods (i.e., advertisements, brochures, radio, and television). Charter anglers relied more on word-of-mouth recommendations and headboat customers were more influenced by previous experiences. Implications for further research are discussed.

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Table 1.—Studies of charter and headboat customers by state, year, author(s), data gathering technique, number of observations, and response rate.

State/year author(s)[1]	Technique	No.	Response rate (%)
Wisconsin, 1974 Dittrich[2]	Mail questionnaire	267	55
Texas, 1978 Ditton et al.	Mail questionnaire	191	46
New York, 1976 Carls	Questionnaire distributed dockside; mail return	413	50
Florida, 1977 Gentle	Questionnaire distributed dockside; mail return	139	—[3]
Mississippi, 1977 Etzold et al.	Mail questionnaire	247	40
Florida, 1978 Browder et al.	Mail questionnaire to operators	560	31
California, 1980 Zangri et al.	On-board passenger questionnaire	4,238	46
	Telephone interview	3,445	81
Delaware, 1983 Falk et al.	Mail questionnaire	583	76
Hawaii, 1985 Samples and Schug	Mail questionnaires to anglers; interviewed dockside	457	62
Alaska, 1986 Coughenower	Mail questionnaire	551	55
Michigan, 1986 Mahoney et al.	Questionnaires distributed dockside; mail return	448	54

[1]All studies focused on charter customers with the exceptions of Carls (1976), Browder et al., (1978) and Falk et al. (1983) which focused on both charter and headboat anglers. Study results by Carls (1976) are aggregated with no differentiation by group possible.
[2]Related papers include Ditton et al. (1975) and Ditton and Strang (1974).
[3]Information not available.

Table 2.—Summary of the age of charter and headboat anglers by selected study.

Angler type, state, year, author(s)	Mean age	Selected age range	Frequency (% in age range)
Charter anglers			
Wisconsin, 1974 Dittrich	42	34-54	54.0
Mississippi, 1977 Etzold et al.	40	—[1]	—[1]
Texas, 1978 Ditton et al.	45	35-54	51.0
Florida, 1978 Browder et al.	42	—[1]	—[1]
Delaware, 1983 Falk et al.	42[2]	30-49	56.9
Hawaii, 1985 Samples and Schug	37	25-44	57.0
Headboat anglers			
New York, 1976 Carls	35[2]	20-39[2]	56.5[2]
Florida, 1978 Browder et al.	41	—[1]	—[1]
Delaware, 1983 Falk et al.	42[2]	30-49	43.9

[1]Information not available in report.
[2]Includes charter and headboat anglers.

2) Motivations to participate in a charter or headboat fishing trip;

3) Anglers' satisfaction regarding key elements of their fishing experience; and

4) Formal and informal sources of promotional and marketing information influencing the angler's decision to participate.

Customer Sociodemographics

Social and demographic information provides a basic profile of charter and headboat anglers. This information is essential for understanding clientele, the potential market available to operators, and marketing strategies to maintain present clientele and locate and capture new customers. In addition, information on anglers' origins, lifestyles, and preferences can indicate the service expected by anglers and ensure that their needs are met. Considering clients' needs and expectations is an effective strategy for shaping clients' perceptions and building loyalty to the operator (DeYoung, 1986). This section focuses on the social and demographic characteristics of charter and headboat anglers (gender, age, income, skill, and group composition). Where possible, findings are presented for charter and headboat groups to facilitate comparisons; otherwise information is inclusive of both groups.

Gender

Studies that include gender as a study variable indicated overwhelmingly that the vast majority of charter/headboat anglers were male. Studies conducted in New York (Carls, 1976), California (Zangri et al., 1980), and Hawaii (Samples and Schug, 1985) found at least 85 percent of the respondents were male. These results were not specific to charter/headboat anglers. National survey results for 1985 indicated that 68 percent of all anglers 16 and older were male (USDI, 1988). Although fishing participation has been dominated by males, Snepenger and Ditton (1985) found a statistically significant trend toward greater female participation in sport fishing during the period 1955-1980.

Age

The literature indicated that the majority of customers ranged between 30 and 55 years of age. Charter anglers had a mean age between 40 and 45 years. Headboat anglers tended to be either younger or older than the selected age range of charter anglers (30-49).

Charter Boats

A consistent finding among studies from Wisconsin (Dittrich, 1974), Mississippi (Etzold et al., 1977), Texas (Ditton et al., 1978), and Florida (Browder et al., 1978) was a mean of 40-45 years of age for charter anglers (Table 2). Dittrich's survey of charter anglers originating from Wisconsin ports on Lake Michigan and the Ditton et al. (1978) study of Texas Gulf Coast charter anglers revealed just over 50 percent of the respondents were between 35 and 54 years of age. The survey of Hawaiian charter anglers (Samples and Schug, 1985) indicated 57 percent of respondents were between 25 and 44 years of age and 25 percent were 45 and over. Only 14 percent were under age 25. In Delaware, 57 percent of charter respondents were between 30 and 49 years of age (Falk et al., 1983).

Headboats

The mean age of Long Island charter/headboat anglers was 35 years (Carls, 1976). Thirty-four percent were between 20 and 29 years of age and 23 percent were between 30 and 39. A survey of Florida's headboat anglers revealed a mean age of 41 years (Browder et al., 1978). Forty-four percent of headboat anglers in Delaware were between 30 and 49 (Falk et al., 1983). Typically, most charter anglers in Delaware ranged between 30 and 49 years, whereas most headboat anglers were usually younger than 30 or older than 49.

Income

Charter anglers tended to have higher annual incomes than headboat anglers. The difference in income levels could be related to the fact that headboat fees are generally less than charter fees and therefore more affordable for lower income anglers.

It was difficult to make generalizations regarding annual income when dollars were not standardized. Reports of annual income were standardized to 1985 dollars

Table 3.—Distribution of anglers by household income category (unstandardized dollars) for selected studies.

Angler type, state, year, author(s)	Income level[1] Under $20,000 (%)	$20,000-29,999 (%)	$30,000-39,999 (%)	$40,000-49,999 (%)	$50,000 or over (%)
Charter anglers					
Wisconsin, 1974					
Dittrich	60.3	33.7 ($20,000 or more)			
Texas, 1977					
Ditton et al.	22.0	26.0	18.0	13.0	21.0
Mississippi, 1977					
Etzold et al.	44.0	56.0 ($20,000 or more)			
Delaware, 1983					
Falk et al.	23.3	34.0	17.5	14.6	10.7
Hawaii, 1985					
Samples and Schug	11.0	11.0 ($20,000-$27,999)	22.0	13.0 ($40,000-$47,999)	36.0 ($48,000 or more)
Michigan, 1986					
Mahoney et al.	7.0	14.7	19.8	14.2	44.3
Headboat anglers					
New York, 1976[2]					
Carls	81.3	14.1	0.0	1.8	2.7
California, 1980					
Zangri et al.	25.8 (under $18,000)	23.3 ($18,000-$27,999)	10.0 ($28,000-$34,999)	7.5 ($35,000-$49,999)	5.4
Delaware, 1983					
Falk et al.	37.7	31.3	17.8	8.2	5.0

[1]Note: Where percents do not add across to 100 percent, income is unknown for remaining percent.
[2]Percentage includes charter and headboat anglers.

using the annual average purchasing power of the dollar (USDOC, 1987:454). In the text, standardized income is presented in parentheses.

Charter Boats

Approximately 34 percent of Wisconsin's Lake Michigan charter anglers reported annual incomes of $20,000 ($43,500) or more (Dittrich, 1974) (Table 3). In contrast, a 1985 study of Michigan's Lake Michigan charter anglers found 58 percent with annual incomes of $40,000 or more and 7 percent with incomes less than $20,000 (Mahoney et al., 1986). A study of Texas charter customers (Ditton et al., 1978) found a mean annual income of $30,000 ($58,700). Seventy-eight percent of the Texas respondents reported incomes above $20,000 ($35,600) with 21 percent having incomes in excess of $50,000 ($88,900). A survey of Mississippi charter boat anglers revealed that 56 percent had annual incomes of $20,000 ($35,600) or more (Etzold et al., 1977). In Delaware (Falk et al., 1983), 43 percent of the charter respondents had an annual income of $30,000 or more ($32,600) and 23 percent had less than $20,000 ($21,600). Almost half (49 percent) of the charter anglers in Hawaii reported annual incomes in excess of $40,000 and 11 percent made less than $20,000 (Samples and Schug, 1985).

Headboats

Surveys of headboat anglers in California (Zangri et al., 1980) and Delaware (Falk et al., 1983) revealed that the income for headboat anglers was slightly less than that of charter anglers. The median income of California headboat anglers was between $18,000 ($23,500) and $23,000 ($30,000). Twenty-six percent of California respondents earned less than $18,000 ($23,500) and 5 percent made over $50,000 ($65,200) annually. In Delaware, 38 percent earned less than $20,000 ($21,600) and 31 percent earned $30,000 or more ($32,400).

The annual income for 81 percent of charter/headboat anglers in New York (Carls, 1976) was less than $20,000 ($37,900). Only 4 percent of respondents had an annual income of $40,000 ($75,800) or more.

Skill

Four studies included anglers' self-perceived level of skill or number of years of fishing experience. These studies indicated that charter/headboat anglers were experienced, with most charter anglers having fished for more years than headboat anglers.

Charter Boats

In Michigan (Mahoney et al., 1986), 56 percent of respondents considered themselves experienced or expert anglers, compared with 13 percent who rated themselves as beginners. Slightly over half (51 percent) had fished for over 26 years and 14 percent had fished less than 5 years.

Headboats

Zangri et al. (1980) found that most California headboat anglers had fished between 6 and 10 years with 17 percent having less than 2 years of experience. However, these figures did not distinguish between anglers who fished once a year on a headboat and those who may have fished more frequently.

Charter and headboat anglers in Delaware had fished in saltwater for an average of 24 years (Falk et al., 1983). In New York, Carls (1976) reported that over half (58 percent) of the charter/headboat anglers had been fishing in saltwater less than 5-6 years. An additional 24 percent of the respondents indicated they had been fishing in saltwater 6-10 years.

Group Composition

Fishing groups on charter/headboat trips usually consist of family, friends, or a combination of the two. A small percentage of charter respondents went fishing alone or with business associates.

Charter Boats

Over 30 percent of these anglers in Alaska (Coughenower, 1986) and Flo-

rida (Browder et al., 1978), 27 percent in Texas (Ditton et al., 1978) and almost 60 percent in Michigan (Mahoney et al., 1986) fished with family members and about one-fourth from these same areas fished with friends. In Wisconsin (Dittrich, 1974) and on the Texas Gulf coast (Ditton ét al., 1978), more trips were taken with friends or a combination of family and friends than with family only. Browder et al. (1978) reported that 32 percent of Florida charter anglers fished with business associates, the second most common group composition in Florida.

Headboats

In Delaware (Falk et al., 1983), 38 percent of the charter/headboat anglers reported they fished with friends, while only 25 percent reported they fished with family members. Six percent said they fished with business associates. Fifty percent of Long Island, N.Y. charter/headboat anglers "always" or "usually" fished with friends and 28 percent with family. Twenty-six percent reported they "always" or "usually" fished alone (Carls, 1976). In Florida, however, headboat anglers were more likely to fish with family members (41 percent) than with business associates (22 percent), or friends (19 percent) (Browder et al., 1978).

Residence Location

Most of charter and headboat anglers resided within their respective states. Those states reporting a greater percentage of out-of-state anglers than resident anglers were Hawaii, Florida, and Delaware.

Motivations for Customer Participation

For operators to better understand a client's expectations of their fishing trip experience, they need to know their motivations for traveling to the coast and for taking a charter or headboat trip. Operators may better identify target markets if they can determine why their customers are in the area—i.e., for a vacation, for business or to fish—and why they seek a charter or headboat fishing experience. The qualities sought in a fishing experience can be measured in terms of a variety of motivations, also defined as anglers' expectations or reasons for participation (Ditton et al. 1978). Knowledge of the charter and headboat angler's motivations provides operators with an additional source of information for determining whether the type of service being provided is satisfactory (Ditton et al., 1978). This section looks at the reasons anglers were traveling on the coast and their motivations for taking a charter or headboat trip.

Reasons for Traveling to the Coast

In the four reports that investigated the customer's primary reason for visiting the coast (Ditton et al., 1975; Etzold et al., 1977; Mahoney et al., 1986; and Coughenower, 1986), over 60 percent went to the coast to fish and relax. In Florida (Gentle, 1977), 44 percent of the customers were on vacation, 34 percent said they were on business and 7 percent said they went to fish and relax. In Delaware (Falk et al., 1983), 67 percent of the anglers reported charter/headboat fishing was the main reason for the visit to the area while the remainder said they would have come to the area even if no boats were available. However, in Hawaii (Samples and Schug, 1985), nearly all respondents (99 percent) said they would have come to Hawaii even if charter fishing was not available. Almost one-third (32 percent) indicated that charter fishing had no influence on their decision to visit Hawaii. Other reasons for traveling to coastal areas included family vacations, to visit friends and relatives, and honeymooning.

Reasons for Taking a Charter or Headboat Trip

The traditional thinking that every angler takes a charter trip just to catch fish has not been supported by previous research (Ditton et al., 1978). Nevertheless, the expectation of catching fish was an important element of the fishing experience for anglers. The importance of the catch motive needs to be understood relative to other noncatch motives such as the desire for excitement, adventure, relaxation, companionship, escape from tension, and appreciation of the outdoors if operators are to meet angler needs.

In several charter surveys, anglers were asked to do one or more of the following: 1) Rank motivations in order of importance, 2) rate the importance of individual motivational items, and/or 3) choose which motivations were important to their decision to participate. To relax or have fun was ranked or rated as one of the most important motives in Wisconsin (Dittrich, 1974), Mississippi (Etzold et al., 1977), Texas (Ditton et al., 1978), Delaware (Falk et al., 1983), Hawaii (Samples and Schug, 1985), and Michigan (Mahoney et al., 1986). The challenge and excitement of the catch and getting away from the normal daily routine were also considered by anglers to be important motives for charter fishing. Less important motives included learning more fishing skills, catching fish to eat, or catching lots of fish.

Although previous studies were not consistent with regard to which recreational motives were included, the idea of relaxing, having fun, and escaping from tension and pressures generally were found to be more important than catching fish. In Delaware (Falk et al., 1983), Michigan (Mahoney et al., 1986), and Hawaii (Samples and Schug, 1985), however, the excitement of experiencing a challenge while fishing was very important to half or more of the respondents. All of the studies reviewed reported that being with friends and/or family was very important, except for customers in Wisconsin (Dittrich, 1974) where fishing with business associates was more important.

Customer Satisfaction

The success of a charter/headboat enterprise depends greatly upon the customers' satisfaction with their fishing experiences and willingness to recommend the boat and/or captain to others. Insight into the factors influencing customers' perceptions of satisfaction and dissatisfaction is key in providing a better experience for the passenger and generating a return customer. Graefe and Fedler (1986) contended that overall satisfaction with a fishing experience is directly related to subjective evaluations of the experience such as perceived attitudes of the

Table 4.—Sources of informal advertising that influenced anglers' choice of captain or boat[1].

Angler type, state, year, author(s)	Informal advertising sources: Word of mouth (%)	Previous experience (%)	Marina visit (%)	Hotel referrals (%)
Charter anglers				
Wisconsin, 1974				
Dittrich	51.0	—[2]	—[2]	—[2]
Mississippi, 1977[3]				
Etzold et al.	56.0	—[2]	—[2]	—[2]
Florida, 1978				
Browder et al.	20.4	34.0	28.7	10.5
Delaware, 1983[3]				
Falk et al.	35.0	67.0	7.3	—[2]
Hawaii, 1985[4]				
Samples and Schug	38.0	17.0	32.0	11.0
Michigan, 1986[3]				
Mahoney et al.	45.9	—[2]	11.2	—[2]
Alaska, 1986[3]				
Coughenower	38.0	14.0	—[2]	—[2]
Headboat anglers				
New York, 1976[3]				
Carls	66.6	—[2]	—[2]	—[2]
Florida, 1978				
Browder et al.	15.0	30.4	20.0	12.0
Delaware, 1983[3]				
Falk et al.	35.0	49.9	3.6	—[2]

[1]Note: This table should be used in conjunction with Table 5. Percentages may not add to 100 percent across the two tables because of miscellaneous sources or varying question and response formats.
[2]Information not available in report.
[3]Respondents could select more than one source.
[4]Percentage of respondents choosing source as "very important."

crew, the desire to catch more fish (targeted species) or a different type of fish, and the perceived fun and relaxation. Situational variables, those characteristics directly observed by the participant, influence overall satisfaction indirectly through their effects on subjective evaluations.

Studies of charter and headboat anglers revealed eleven variables (subjective and situational) thought to contribute to customer satisfaction. They were: 1) Safety, 2) expected catch, 3) captain's skills, 4) job performance, 5) presence of family and friends, 6) safe navigation, 7) boat condition, 8) price, 9) weather, 10) services provided, and 11) location or scenery. Two subjective variables were most frequently evaluated as important to angler satisfaction: Skills and performance of the captain and crew and the safety precautions provided for anglers.

Ninety percent of the anglers interviewed in Hawaii considered safety and the captain's skills very important to the positive evaluation of their experience (Samples and Schug, 1985). More than one-fifth of charter and headboat anglers surveyed in Delaware indicated the captain and crew were key factors in their enjoyment of the charter experience (Falk et al., 1983). Over half (56 percent) of New York anglers (Carls, 1976) also considered a courteous and helpful crew to be very important to the overall enjoyment of the fishing trip. In their study of Lake Michigan charter operators, Ditton and Strang (1974) indicated that 21 percent of the anglers rated safety factors as very important.

The presence of family and/or friends was more important to an angler's enjoyment of the trip than meeting with business associates. A successful fish catch was mentioned as a high point by anglers in Alaska (Coughenower, 1986), Delaware (Falk et al., 1983), and New York (Carls, 1976). Charter cost was considered by anglers in their overall evaluation of trip satisfaction. In evaluating their charter/headboat fishing experience, the studies reviewed indicate that anglers put more weight on their perceptions and evaluations of subjective indicators than on situational factors. This is consistent with previous study findings reported by Graefe and Fedler (1986).

Influential Information Sources

In addition to basic information on angler characteristics and expectations, the operator needs an understanding of the factors influencing the angler's decision to go charter fishing. For example, an understanding of the extent to which marketing and advertising promotions influence anglers can help operators to initiate or modify their marketing strategies to meet business goals (Dittrich, 1974).

Sources Influencing Anglers' Choice of Boat or Captain

Word-of-mouth recommendation was the most frequently used source of information and most effective method of attracting new customers to a particular boat or captain. A successful previous experience with a captain or visiting the dock also influenced boat choice. These findings indicated that a vast majority of charter and headboat anglers surveyed nationwide chose to fish with a particular charter or headboat business for reasons other than exposure to formal advertising.

Charter Boats

About half of the charter anglers in Wisconsin (Dittrich, 1974), Mississippi (Etzold et al., 1977), and Michigan (Mahoney et al., 1986) responded that their choice of boat was most influenced by word-of-mouth recommendations (Table 4). In Hawaii (Samples and Schug, 1985) and Alaska (Coughenower, 1986), 38 percent of the anglers relied on verbal recommendations. A plurality of anglers in Florida (Browder et al., 1978) and Delaware (Falk et al., 1983) indicated that a successful previous fishing experience with the captain was most important in influencing their decision. However, 50 percent of the charter anglers in Hawaii said previous experience with the captain was not important, which suggested most were tourists with few return customers. Fifty-seven percent of Delaware charter anglers also indicated that the boat's reputation was important to their decision. Visits to the

Table 5.—Sources of formal advertising that influenced customers' choice of captain or boat[1].

Angler type, state, year, author(s)	Formal advertising sources: Magazine/ newspaper (%)	TV/ radio (%)	Bro- chures (%)	Yellow pages (%)	Sport shows (%)	Miscell.[2] advt. (%)
Charter anglers						
Wisconsin, 1974						
Dittrich	4.5	9.7	10.9	7.1	1.8	10.9
Mississippi, 1977[3]						
Etzold et al.	—[4]	—[4]	7.0	5.0	—[4]	8.0
Florida, 1978						
Browder et al.	—[4]	—[4]	—[4]	—[4]	—[4]	4.3
Delaware, 1983[3]						
Falk et al.	2.8	—[4]	—[4]	—[4]	1.0	—[4]
Hawaii, 1985[5]						
Samples and Schug	22.0	14.0	—[4]	—[4]	—[4]	24.0
Michigan, 1986[3]						
Mahoney et al.	8.8	1.7	19.3	—[4]	5.3	14.3
Alaska, 1986[3]						
Coughenower	2.0	—[4]	—[4]	—[4]	1.0	—[4]
Headboat anglers						
New York, 1976[3]						
Carls	18.3	—[4]	10.5	—[4]	—[4]	—[4]
Florida, 1978						
Browder et al.	—[4]	—[4]	—[4]	—[4]	—[4]	20.0
Delaware, 1983[3]						
Falk et al.	5.2	—[4]	—[4]	—[4]	—[4]	

[1]Note: This table should be used in conjunction with Table 4. Percentages may not add to 100 percent across the two tables because of miscellaneous sources or varying question and response formats.
[2]Miscellaneous advertising includes signs, chambers of commerce, reservation services, local stores, and other businesses.
[3]Respondents could select more than one source.
[4]Information not available in report.
[5]Percentage of respondents choosing source as "very important."

marina and hotel referrals were an important influence to anglers' decisions in Florida and Hawaii, states with the largest out-of-state fishing clientele.

Formal advertising methods were not as important in prompting a customer's boat selection as the informal promotional methods listed in Table 5. Miscellaneous advertising sources, including chambers of commerce, reservation services, signs, local stores, and other businesses prompted 11 percent of Wisconsin anglers (Dittrich, 1974), 8 percent of Mississippi anglers (Etzold et al., 1977), 4 percent of Florida anglers (Browder et al., 1978), 24 percent of Hawaii anglers (Samples and Schug, 1985), and 14 percent of anglers in Michigan (Mahoney et al., 1986) to select a particular charter boat. Brochures were relied upon by 19 percent of Michigan charter anglers (Mahoney et al., 1986) and by less than 7 percent of the anglers in Florida (Browder et al., 1978) and Mississippi (Etzold et al., 1977). Magazine or newspaper articles influenced less than 9 percent of anglers in Wisconsin (Dittrich, 1974), Michigan (Mahoney et al., 1986), Delaware (Falk et al., 1983), and Alaska (Coughenower, 1986) and 22 percent in Hawaii (Samples and Schug, 1985).

Headboats

Responses of headboat anglers in Florida (Browder et al., 1978) and Delaware (Falk et al., 1983) were consistent with those of charter boat anglers from their respective states in that they relied more heavily on a previous experience. Respondents in these two states considered a previous experience to be the most influential factor when selecting a particular boat or captain. In New York (Carls, 1976), most charter/headboat anglers were influenced by word-of-mouth and by newspapers or other media advertisements.

Although few anglers indicated they were influenced by formal marketing tools, this does not necessarily discount their importance. Formal advertising may have instilled a desire in people to go fishing which was not immediately recognized by the customer. It appeared, however, to have had little impact on the decision as to which captain or boat was selected.

Discussion

The purpose of the literature review was to synthesize published research findings regarding charter and headboat anglers in order to make generalizations regarding their social and demographic characteristics, motivations, and attitudes. This information can be used by operators as an initial data base for customer-related information. Understanding customers' background can provide essential information to establishing the service expected. Although a generalized profile of charter and headboat anglers is provided in the review, it must be understood that there is no "average" charter or headboat angler. Operators need to understand the needs and expectations of each customer or segment of customers they serve. With greater understanding of clientele and how they make decisions, operators can make more effective use of materials on services marketing techniques developed previously for the industry by PNR and Associates (1985). DeYoung (1986), and Falk and Savini (1987).

Charter and headboat operators need to recognize that they are marketing a unique service. It is important that they provide a quality experience to their customers since the vast majority of anglers report they are influenced by word-of-mouth recommendations. Considering each individual angler's needs and ensuring that those needs are met is a strategy for encouraging positive customer satisfaction and loyalty (DeYoung, 1986).

Implications for Future Research

Research on charter and headboat anglers developed over the previous 15 years has implications for future work. The literature provides wide coverage of charter and headboat anglers (i.e., the Atlantic, Pacific, and Gulf coasts plus the Great Lakes, Hawaii, and Alaska). Further, there is sufficient agreement among studies to produce generalizations that

can be verified elsewhere. Thus, it can be argued that there is little need for additional in-depth descriptive studies of charter and headboat anglers. The next generation of studies will need to solve methodological problems and focus on questions of concern to resource managers and boat operators.

Methodologically, there are problems with response rates, incomplete sampling frames, extension of findings, and data collection techniques in previous studies of charter and headboat anglers. First, response rates with this group of anglers have generally lagged behind those of other angler surveys. Although there may be several reasons for this, mail survey instrumentation and procedures may be ill conceived. None of the studies reviewed included any citations for the survey methodology used such as Dillman (1978) and Sheskin (1985). Dillman (1978:21) reported a 74 percent response rate across 48 mail surveys. Of the studies reviewed, only one (Falk et al., 1983) that used a mail survey achieved a response rate of >70 percent. This was probably due to the development of a mailing list of customers over the fishing season and three staggered mailings to ensure a short recall period.

Second, there is often no reliable sampling frame or listing of charter and headboat anglers. We have found that operators generally keep poor clientele records, often mixing customers from various years with individuals making inquiries. When these records are used for sampling purposes, the researcher may be contacting individuals who went fishing many years ago (or not at all) and are unable to respond to questions. Worse yet, these respondents may bias results with recalled information. Often, operators will not make customer lists available for research purposes. Consequently, further consideration needs to be given to nonprobability techniques like purposive and quota sampling (Babbie, 1989).

Third, a telephone follow-up check on nonrespondents would be useful for investigating differences between respondents and nonrespondents on selected items, i.e., overall fishing frequency in previous 12 months, charter or headboat fishing frequency in the previous 12 months, species preference, expenditures, etc. This check may indicate that respondents are significantly different from nonrespondents, making extension of findings to the entire sample erroneous (Brown et al., 1981; Becker et al., 1987). Also, this would identify the extent to which individuals should not have been included in the sampling frame. Only two of the studies reviewed in this paper included a check on nonrespondents, and they found no differences (Samples and Schug, 1985; Mahoney et al., 1986).

Finally, alternative data collection techniques need to be considered. Although telephone interviews produced the highest response rate (81 percent) of the studies reviewed, the technique was effective because it followed an on-board questionnaire. There was little difference in response rates when questionnaires were mailed to anglers or when questionnaires were distributed at dockside and anglers were asked to return them. The studies by Samples and Schug (1985) and Falk et al. (1983) were exceptions to this pattern. Any technique that provides broad temporal and spatial coverage of charter and headboat anglers (without reliance on operators' clientele lists) should receive further consideration. Although these techniques will be more costly and labor intensive, they will likely yield more reliable and valid results.

Researchers need to build upon current understandings of charter/headboat clientele to focus on the pressing issues that have resulted from greater regulation of fisheries. As the industry is impacted by new regulations, for example, there is a need to know if there has been a "succession" in clientele. Are more experienced anglers being replaced by less experienced anglers (turnover), and what are the implications for the boat operator? These questions cannot be answered using cross-sectional surveys; this can only be accomplished with longitudinal research designs.

Second, more research attention should be focused on identifiable market segments of charter and headboat anglers. The diversity within the overall angler group needs to be explored more fully to respond to specific questions being asked by fishery managers regarding regulatory impacts and to more effectively focus promotional efforts by operators. Examples of these market segments include anglers by species preference, local anglers, winter visitors, sales and other business associates, etc. The number of observations in future studies will probably need to be increased to have sufficient sample size for subgroups of managerial or business interest.

Finally, although previous studies have provided insight into charter and headboat angler preferences, we have little understanding of how anglers make tradeoffs between items like price, quality of fishing, quality of service, and ability to catch a preferred species (i.e., Schug, 1985). More studies using conjoint measurement techniques (Cattin and Wittink, 1982, Green and Srinivasan, 1978) are needed to identify the combination of factors most valued by anglers so operators can implement appropriate marketing strategies. Future studies of charter and headboat anglers will need to be issue oriented, theoretically driven, and well grounded on previous descriptive work.

Acknowledgments

This research was funded by the National Marine Fisheries Service with Saltonstall-Kennedy Program funding (Contract No. NA86WC-H-06107) and the Texas Agricultural Experiment Station, Texas A&M University, College Station. We acknowledge helpful review comments from Chad Dawson, Bruce DeYoung, Jim Falk, John Schwartz, and two anonymous reviewers.

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A Review of World Salmon Culture

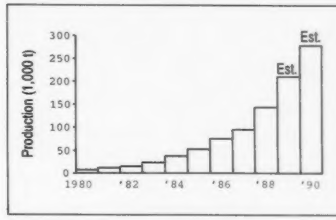

Figure 1.—World farmed salmon production (1,000 t), 1980-90.

Introduction

World farmed salmon production reached 145,000 metric tons (t) in 1988 and an estimated 217,000 t in 1989. The latter figure is comparable to the U.S. annual salmon catch (about 250,000 t) and is approaching one-third the size of the world wild salmon catch (about 700,000 t). The rapid expansion of farmed salmon supplies in the late 1980's has led to sharp price decreases. Lower prices have forced some farmers out of business, but at the same time, a large number of farmers first began harvesting salmon on a commercial scale as the 1980's ended. Farmed salmon production could exceed 270,000 t in 1990.

Most salmon farmers raise Atlantic salmon, *Salmo salar*, reflecting the fact that farming technology was developed in Europe. The world's largest farmed salmon producer is Norway, accounting for about half of total production in 1988-1989. In early 1990, Norwegian producers for the first time announced plans to freeze significant quantities of salmon for export. The action is intended to protect the huge Norwegian industry by stabilizing fresh salmon prices, but it could also adversely affect frozen salmon exporters in the United States.

Apart from Norway, other European countries have also developed major salmon farming industries.

Important European Community (EC) producers include the United Kingdom (Scotland) and Ireland. Canada, Japan, and Chile have become major producers of Pacific salmon species in recent years. New Zealand and Australia are still in the early stages of development but could become major salmon producers in the 1990's.

Note: This report, IFR-90/30, was prepared by Brian D. McFeeters, Foreign Affairs Assistant, Office of International Affairs, NMFS, NOAA, Silver Spring, MD 20910. Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Growth

Salmon culture emerged as a major economic activity during the 1980's. At the beginning of the decade, salmon farming was a novel undertaking. World production, almost exclusively from Norway and Japan, amounted to only 7,000 t. The chief difficulties for aquaculturists, as the decade began, were technical. Farmers had to develop profitable methods of raising salmon, while facing the danger that disease, predators, or storms could wipe out their entire stock. As the 1980's ended, the situation was considerably different. World production levels had increased 30-fold, reaching an estimated 217,000 t in 1989 (Fig. 1, Tables 1, 2). Norway was still the

Table 1.—World farmed salmon production, 1980-89, with projections for 1990[1].

	Production, live weight (t)										
Nation	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
EC											
France	30	40	40	40	50	60	60	60	60	60	600
Ireland	21	35	100	257	385	722	1,500	2,232	4,200	7,300	10,000
Spain	0	0	0	0	100	150	150	200	300	450	600
UK	598	1,333	2,136	2,536	3,912	6,921	10,338	12,721	17,951	31,015	35,000
Subtotal	649	1,408	2,276	2,833	4,447	7,853	12,048	15,213	22,511	38,825	46,200
Non-EC Eur.											
Faroe Isl.	0	0	60	105	116	470	1,370	3,500	3,400	8,000	10,000
Finland	0	30	30	30	94	100	100	127	150	170	200
Iceland	0	20	30	50	107	91	123	530	1,233	3,900	8,600
Norway	4,143	8,422	10,266	17,000	25,936	33,796	49,985	56,204	83,700	114,866	150,000
Sweden	0	0	10	15	59	81	160	224	363	500	500
Subtotal	4,143	8,472	10,396	17,200	26,312	34,538	51,738	60,585	88,846	127,436	169,300
N. America											
Canada											
Atlantic	11	21	38	68	222	349	646	1,350	3,100	3,150	3,250
Pacific	157	176	273	128	107	120	400	1,362	6,000	14,500	20,000
Subtotal	168	197	311	196	329	469	1,046	2,712	9,100	17,650	23,250
U.S.											
Atlantic	0	0	0	0	23	68	136	800	1,700	3,200	5,200
Pacific	329	873	691	844	1,225	1,752	1,264	1,700	2,000	2,400	2,500
Subtotal	329	873	691	844	1,248	1,820	1,400	2,500	3,700	5,600	7,700
N. Am. total	497	1,070	1,002	1,040	1,577	2,289	2,446	5,212	12,800	23,250	30,950
Other											
Chile											
Atlantic	0	1	184	94	109	500	897	1,138	2,900	5,308	8,000
Pacific	0	0	0	0	0	0	0	57	200	1,200	4,500
Subtotal	0	1	184	94	109	500	897	1,195	3,100	6,508	12,500
Japan	1,855	1,159	2,122	2,760	5,049	6,990	7,533	12,177	16,400	18,600	20,000
New Zealand	0	2	5	10	10	250	500	1,000	1,250	2,000	3,000
Subtotal	1,855	1,162	2,311	2,864	5,168	7,740	8,930	14,372	20,750	27,108	35,500
Grand total	7,144	12,112	15,985	23,937	37,504	52,420	75,162	95,382	144,907	216,619	281,950

[1]Note: Excludes data for Australia, with Atlantic salmon production of 380 t in 1988-89 and a projected 1989-90 production of 2,000 t.

largest producer, accounting for over half of the total, but several other nations had developed sizable salmon farming industries (Fig. 2). Another group of nations had begun to farm salmon on a commercial scale in the mid-1980's and was poised to rapidly expand production as the decadc ended. Many of the earlier technical difficulties of salmon farming had been overcome through experience and extensive research.

Impressive advances in the production of farmed salmon in the late 1980's have created new difficulties. Early in the decade, farmed salmon was a rarity on world markets, priced as a luxury food. By 1989, however, producer prices for farmed salmon had fallen sharply as exporters placed ever-increasing quantities on the market. For large producing nations, such as Norway, the decline in salmon prices disturbed what had become a major sector of the fishing industry. For salmon farmers in other countries, many of them still paying high start-up costs, falling prices posed a more serious threat. As the 1990's began, the world's salmon farming industry faced great uncertainty: Neither prices nor production levels had stabilized.

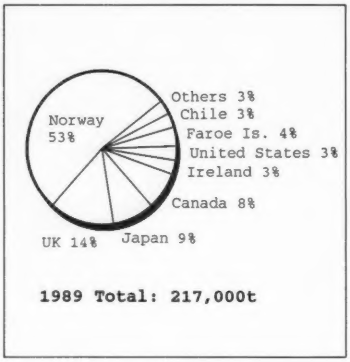

Figure 2.—Farmed salmon production by major producing nations, 1989 (est.).

Recent Trends

Prices

Fresh salmon prices declined gradually during most of the 1980's as farmed salmon supplies increased. In the UK, for example, fresh salmon prices declined by 30 percent from 1980 to 1987 (Shaw, 1989:28). During 1988-89 when supplies of farmed salmon surged, steadily declining prices became a major concern for salmon producers. Between January 1988 and December 1989, Norwegian farmed salmon prices fell by 40 percent (from about $4.00/lb to $2.30/lb) in Europe's largest wholesale market near Paris (Fig. 3). Prices recovered somewhat in early 1990, but remained well below $3.00/lb. Lower prices have severely reduced profit margins: One 1987 study estimated farmed salmon production costs in Europe at $2.00-$2.50/lb (DPA Group, Inc., 1989).

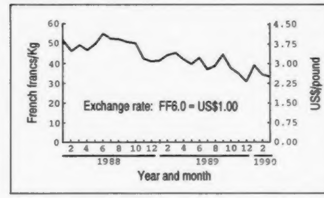

Figure 3.—Average prices (Rungis, France) for Norwegian farmed salmon, 1988-90.

Producer Reaction

In the face of falling prices, salmon farmers appear unwilling to allow market forces to determine the future of their industry. EC producers have alleged that Norwegian salmon farmers are selling at below cost, or "dumping," fresh salmon in the EC market. Norwegians dispute this charge. Even so, Norwegian producers, whose exports have a large impact on fresh salmon markets worldwide, limited the expansion of their fresh salmon exports in 1989, and they indicated that they would limit fresh salmon supplies in 1990 as well.

Technical Issues

Although many technical issues plaguing early salmon farmers have been resolved, others have grown more acute. To compete in world markets, many farmers opted for intensive farming methods, raising salmon under high-density conditions. While these methods permit increased yields, they also place the fish under stress, making them vulnerable to a variety of pathogens, and increasing the chances that one diseased fish will infect others. Unduly stressed salmon have even suffered heart attacks. Researchers have developed many effective vaccines and medications as well as other methods to treat salmon raised under high-density conditions. While

Table 2.—World production of farmed Atlantic and Pacific salmon, by species group, 1980-89 with projections for 1990[1].

Salmon type and nation	Production, live weight (t)										
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Atlantic salmon											
Canada, Atl.	11	21	38	68	222	349	646	1,350	3,100	3,150	3,250
Chile	0	1	184	94	109	500	897	1138	2900	5308	8000
Faroe Isl.	0	0	60	105	116	470	1,370	3,500	3,400	8,000	10,000
Finland	0	30	30	30	94	100	100	127	150	170	200
France	30	40	40	40	50	60	60	60	60	60	600
Iceland	0	20	30	50	107	91	123	530	1,233	3,900	8,600
Ireland	21	35	100	257	385	722	1,500	2,232	4,200	7,300	10,000
Norway	4,143	8,422	10,266	17,000	25,936	33,796	49,985	56,204	83,700	114,866	150,000
Sweden	0	0	10	15	59	81	160	224	363	500	500
UK	598	1,333	2,136	2,536	3,912	6,921	10,338	12,721	17,951	31,015	35,000
U.S.	0	0	0	0	23	68	136	800	1,700	3,200	5,200
Subtotal	4,803	9,902	12,894	20,195	31,013	43,158	65,315	78,886	118,757	177,469	231,350
Pacific salmon											
Canada, Pac.	157	176	273	128	107	120	400	1,362	6,000	14,500	20,000
Chile	0	0	0	0	0	0	0	57	200	1,200	4,500
Japan	1,855	1,159	2,122	2,760	5,049	6,990	7,533	12,177	16,400	18,600	20,000
New Zealand	0	2	5	10	10	250	500	1,000	1,250	2,000	3,000
Spain	0	0	0	0	100	150	150	200	300	450	600
U.S.	329	873	691	844	1,225	1,752	1,264	1,700	2,000	2,400	2,500
Subtotal	2,341	2,210	3,091	3,742	6,491	9,262	9,847	16,496	26,150	39,150	50,600
Grand total	7,144	12,112	15,985	23,937	37,504	52,420	75,162	95,382	144,907	216,619	281,950

[1]Note: Excludes data for Australia Atlantic salmon production (1989-90 est. 2,000 t).

these measures are effective, there is some concern among consumers—and therefore among farmers also—about the use of such medical additives in the production of salmon.

Smolts

Concern over the spread of disease has also led many nations to reduce or curtail their imports of salmon eggs and smolts (juvenile salmon). In Iceland, which entered the salmon industry mainly as an exporter of smolts, the disappearance of foreign markets has prompted an expansion of domestic salmon farming. In other nations, the governments operate smolt hatcheries to assist farmers. Lately, however, there is a trend toward vertical integration of salmon farms among the larger producers. Some salmon farmers in Norway, Scotland, and Canada now breed salmon in their own hatcheries.

Technological and Environmental Issues

The technology of salmon farming is becoming sophisticated, helping farmers to remain competitive even when they are forced to raise salmon under difficult offshore conditions. Movable floating sea-cages, automated feeding equipment, and waste filtering systems are increasingly common. Norway has led the way in developing technology, but smaller producing countries have also introduced innovations. In France, aquaculturists are attempting to raise salmon in a converted oil tanker.

Environmental considerations are closely connected with the technical issues involved in salmon farming. As salmon farms have expanded, becoming an industry rather than a novelty, they have sparked opposition from groups concerned with coastal pollution, the purity of wild salmon stocks, and other ecological issues. Local fishermen sometimes object to the waste excreted by farmed salmon. In Ireland, environmental groups have objected to the installation of salmon farms on scenic stretches of coast which are important for tourism. Because of opposition to the use of coastal sites, many salmon farms are being installed offshore.

Ranching

The term "salmon ranching" refers to the practice of releasing juvenile salmon into the ocean for later recapture. While less important than farming as a source of cultured salmon, ranching has recently expanded in several countries. Salmon ranching is not covered in detail in this report, but it is an activity with substantial potential in the 1990's. There are two types of salmon ranching. In the first, widely practiced in Japan, the juvenile salmon released into the ocean are later caught by coastal fishermen. This method, which adds to the existing wild salmon populations, accounts for most of Japan's 150,000 t annual catch of chum salmon (Tashiro, 1988). Other nations, including Iceland, have also engaged in this kind of salmon ranching. This second type of ranching is more closely related to salmon farming. Instead of allowing the salmon to be caught at sea, ranchers rely on the natural tendency of salmon to return to their river (or, in this case, coastal ranch site) of origin. Though ranchers have had mixed success in actually recapturing mature salmon, this method appears to have two potential advantages over conventional farming: Production costs could be quite low, since salmon are raised at sea; ranchers may be able to promote their product as being indistinguishable from pure wild salmon.

Species Discussed and U.S. Salmon Farming

The term "Atlantic salmon" used in this report refers to *Salmo salar*, the species raised throughout Europe, with few exceptions. The term "Pacific salmon" refers to a group of related species: Coho or silver salmon, *Oncorhynchus kisutch*; chinook or king salmon, *O. tshawytscha*; cherry salmon, *O. masou*; sockeye or red salmon, *O. nerka*, and chum salmon, *O. keta*. The species produced in a particular country is (are) identified in the text.

Salmon farming in the United States, not covered in this report, yielded an estimated 5,600 t of salmon in 1989, making the United States the eighth largest cultured salmon producer (Table 1). Farmers in the United States produce both Atlantic and Pacific (mostly chum) salmon.

Norway

Norway produces Atlantic salmon exclusively. In 1988, production was 83,700 t, while 1989 production of the species was estimated at 115,000 t.

Production

Norway dominates the world farmed salmon industry. In 1989, it produced over half of the world's farmed Atlantic salmon. As the world's pioneer in salmon culture, Norway has enjoyed a spectacular record of success. All sectors within the industry—smolt producers, feed manufacturers, salmon farmers, and salmon exporters—have shared in a remarkable era of growth (Fig. 4). This growth has not been achieved without difficulties, however. The sharp Norwegian production increases in recent years—an estimated 115,000 t in 1989 compared with 83,700 t in 1988 and 56,000 t in 1987—

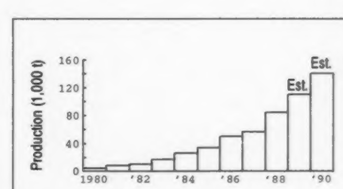

Figure 4.—Norwegian farmed Atlantic salmon production (live weight), 1980-90.

have disrupted salmon markets throughout the world. The quantities of salmon reaching commercial size have become difficult for even the skillful Norwegian exporters to market.

As production increased, salmon prices declined substantially in 1989 (Fig. 3), impairing the profitability of the industry. By late 1989, prices received by Norwegian farmers for large Norwegian salmon had fallen to about $4.90/kg ($2.22/lb), less than half of their 1987 levels. Norwegian salmon farmers were predicting operating losses of as much as $29 million for 1989.

Norway's production of farmed salmon could have been higher in 1989. Some industry representatives had predicted harvests as high as 150,000 t. However, when the rapid increase in world supplies of farmed salmon caused prices to decline, Norwegian salmon farmers began to scale back their production estimates. To prevent further price erosion, farmers intentionally limited harvests to 115,000 t—still a record level—instead of the estimated 140,000 t of salmon that were approaching market size.

This self-imposed restraint on 1989 production means that Norwegian farmers carried over substantial "inventories" of penned harvestable salmon, raising the possibility that additional supplies of fresh Norwegian salmon would be brought to market in early 1990. Recognizing the continuing threat to profits, the Norwegian salmon farming industry took strong action to shore up prices in the short term and to limit supplies of fresh salmon in the long term. The Norwegian Fish Farmers Sales Organization (NFFSO) has announced plans to buy and freeze 20,000-40,000 t of salmon. The Organization plans to borrow $200 million from private banks to finance the freezing plan, and will impose a levy of $0.75/kg on all exports of fresh salmon in 1990 to pay off the loan. Odd Ustad, director of the NFFSO, stated that the combination of the freezing plan and the tax on exports should keep 1990 prices to producers of fresh salmon at about $6.30/kg ($2.86/lb). This action, intended to protect prices in the fresh salmon market, will have an important indirect result: It will significantly increase Norway's involvement in the frozen salmon market, an area in which Norway has played only a limited role in the past.

Table 3.—Norwegian exports of farmed salmon by country of destination, quantity, and values, 1987-88.

Country of destination	1987 Quantity $ in 1,000 t	1987 Value million dollars	1988 Quantity $ in 1,000 t	1988 Value in million dollars
France	11.3	83.6	18.7	130.1
Denmark	7.7	51.8	14.2	92.1
U.S.	7.8	60.3	9.9	76.5
F.R.G.	4.7	37.9	7.5	56.6
Japan	1.3	10.2	3.0	23.4
Other	9.2	69.8	14.8	107.4
Total	42.0	313.6	68.1	486.1

Farms

There have been about 600 salmon farms operating in Norway since the mid-1980's. Although the number of farms has not increased significantly, potential farming capacity expanded in 1988, when the Norwegian Government permitted fish farmers to increase the size of individual farms from 8,000 m^3 to 12,000 m^3. Smolt production reached a peak of 75 million in 1988, but declined to an estimated 62 million in 1989.

Exports

Norway's exports of farmed salmon have increased tenfold over the past decade, from $43 million in 1979 to $486 million in 1988. The EC is the principal market for Norwegian salmon exports (Table 3). In 1988, over 60 percent of such exports were sold to EC nations, about 15 percent went to the United States, and 5 percent to Japan. In 1988, the three largest salmon exporters in Norway were the Skaarfish (sales of over $100 million), Domstein, and Hallvard Leroy companies.

According to preliminary reports, Norway exported an estimated 100,000 t of salmon, worth $585 million, in 1989. As in previous years, the largest markets for farmed salmon exports were in the EC, principally France, Denmark, and the Federal Republic of Germany. Exports to the United States increased in quantity to 11,400 t, but declined in value to $67 million. Shipments to Japan increased to almost 4,700 t.

Norway's increasing salmon exports to the EC have become controversial. During 1989, Scottish and Irish salmon farmers alleged that Norwegians were dumping under-priced salmon in the EC market, thereby threatening producers in other countries. In February 1990, the European Commission announced that it would investigate the charges. The EC has never before investigated alleged dumping of a food product, and the criteria for such an investigation may be difficult to establish. Norwegian salmon exporters face similar protests in the United States. U.S. producers of Atlantic salmon filed anti-dumping and countervailing duty complaints against Norway in February 1990.

As their European and U.S. markets have become somewhat problematic, Norwegian salmon farmers have turned increasing attention to the huge Japanese market for salmon, as indicated by the growing share of fresh salmon exports shipped to Japan in 1989. In 1990, Norway may also attempt to sell a significant portion of its frozen salmon production—estimated at 40,000 t—to Japanese importers. However, the U.S. Embassy in Tokyo reported in early 1990 that the Japanese salmon market was oversupplied and that Japanese importers would not accept large quantities of Norwegian frozen salmon unless prices declined significantly. Such a price decline would probably also affect U.S. exports of frozen salmon to Japan.

Outlook

Norwegian salmon farmers faced an uncertain market during late 1989 and early 1990, as evidenced by their decision to delay the harvest of some salmon and to freeze excess quantities as they are harvested. (It is not known whether Norway will continue to freeze salmon in future years.) This uncertainty means that forecasts of Norway's farmed salmon production for 1990 and beyond are extremely tentative. The NFFSO has asked salmon farmers to limit production of both salmon and smolts. Though a 140,000 t salmon harvest is currently being forecast for 1990, market conditions—rather than production capacity—may dictate lower production levels.

Continuing annual increases in Norway's farmed salmon production are no longer assured.

Faroe Islands

Salmon culture in the Faroe Islands is also limited to the Atlantic salmon. In 1988, 3,400 t were harvested, and the figures more than doubled in 1989 to an estimated 8,000 t.

Production

The Faroe Islands, a self-governing province of the Kingdom of Denmark, has rapidly increased its production of farmed salmon since the mid-1980's (Fig. 5). Production first reached 1,000 t in 1986. Harvests have increased since then, but Faroese salmon farmers have also faced setbacks. Losses from fish diseases and algae blooms hurt 1988 production, which reached only 3,400 t instead of the expected 4,200 t. In addition, many salmon farms were destroyed in late 1988 when severe storms—the worst in 100 years—raged through the Islands, with winds of up to 150 miles per hour. Despite these difficulties, production of farmed Atlantic salmon recovered in 1989 and reached an estimated 8,000 t, more than double the 1988 level.

Salmon farming has taken on increasing importance in the Faroe Islands—where catching and processing fish is the mainstay of the economy—because of the downturn in wild fishery catches in recent years. Faroese fishermen invested heavily in high-seas trawlers, but have lost their access to traditional distant-water fishing areas off Greenland and Norway.

The Faroese Home-Rule Government supported the start of the salmon farming industry by providing technical assistance and investment loans to fish farmers. Besides providing essential financial support, the Government has also regulated the industry in several ways. The importation of smolts is prohibited in order to protect Faroese salmon from diseases and the number of farms is limited in order to protect the environment.

The Government's prohibition on the import of salmon smolts at first limited the growth of the Faroese salmon farming industry; all smolts had to come from the Government-run hatchery. Salmon farming expanded rapidly after 1984, when the new Government allowed individual farmers to operate their own hatcheries. By 1987, smolt production was estimated at 3 million fish per year.

Farms

There were about 50 salmon farms in the Faroe Islands in 1989, producing an annual average of 160 t of salmon. Most salmon farmers make use of sea-cages located in narrow fjords, but the Government has encouraged farmers to use offshore cages because of environmental concerns. There were 17 offshore cages operating in 1989.

Exports

The bulk of the farmed salmon produced in the Faroe Islands is exported. In 1987 (the latest year for which export data are available), the Islands exported 82 percent of the cultured salmon produced. The bulk of these exports (95 percent) were shipped to the EC, especially to Denmark (Table 4). The United States purchased $1 million worth of farmed salmon from the Faroe Islands in 1987, but only $236,000 worth in 1989.

Outlook

The conservative Faroe Islands Government elected in 1989 entered office facing a $1 billion debt. This sum, inherited from former governments that spent heavily for social welfare, makes increased aid to salmon farmers unlikely. Salmon farming is expected to continue expanding at a moderate pace—1990 production was forecast at 10,000 t.

Iceland

Production

Salmon farming in Iceland first reached commercial scale in 1987, when farmers produced 530 t. Since then, production has more than doubled each year, to 1,200 t in 1988, and to an estimated 3,900 t in 1989 (Fig. 6). Although Iceland does not rival either Norway or the UK as a producer of market-sized salmon, the nation has played an important role in the development of the salmon aquaculture industry as an exporter of salmon smolts. The island's geothermal resources were

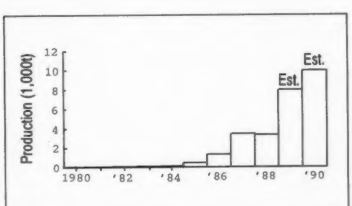

Figure 5.—Faroe Islands' farmed Atlantic salmon production (live weight), 1980-90.

Table 4.—Faroe Islands exports of farmed salmon by country of destination in amount (t) and value ($1,000), 1987.

Destination	1987 Amt.	1987 Value	Destination	1987 Amt.	1987 Value
Denmark	1,061	7,300	UK	45	300
France	598	4,700	Belg.-		
F.R.G.	542	4,400	Luxem.	42	400
Spain	322	2,600	Norway	32	300
U.S.	112	1,000	Others	10	100
Italy	68	400			
Netherl.	47	300	Total	2,880	21,800

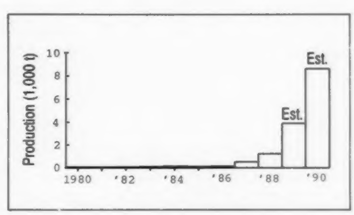

Figure 6.—Icelandic farmed Atlantic salmon production (live weight), 1980-90.

harnessed to provide temperature-controlled water for over 50 hatcheries. Production of smolts for several years exceeded the farming capacity in Iceland, so millions of smolts were exported in the mid-1980's, mostly to Norway and Ireland.

In recent years, Iceland has reduced its exports of smolts because foreign markets have largely evaporated, but it has continued to increase smolt production to supply its growing domestic industry. In both 1988 and 1989, over 10 million smolts were raised (compared to 4 million in 1987), none of which were exported, indicating that Icelandic salmon production may exceed 8,000 t in 1990.

Foreign investment and Government assistance have played important roles in the development of Iceland's salmon farming industry. Norwegian companies had invested over $45 million in Icelandic salmon culture and equipment as of 1987, the latest year for which such data were available. This amount was one-third of the total investment in the salmon farming industry. The Icelandic Government has provided additional impetus to salmon farmers by offering low-cost financing. During 1989, as Icelandic salmon farmers began feeling the impact of lower world salmon prices, the Icelandic Prime Minister proposed a Government initiative to address financial problems in the aquaculture sector.

Farms

About 60 salmon farms operated in Iceland in 1989 and about 20 salmon ranching enterprises. In recent years, the number of fish farms has not increased rapidly, but culturists have begun to make greater use of their farms' capacity. They have placed the bulk of the smolts in seacages, similar to those used by other nations. Because Iceland's bays and inlets are not as well protected as those in Norway or Scotland, some Icelandic farmers have installed land-based farms.

Salmon farmers in Iceland were hard hit in 1989 by the decline of their smolt export markets and the decrease in world salmon prices. At least 10 farms filed for bankruptcy late in the year. One of the failed companies was Islandlax, a joint venture between Iceland's Samband cooperative association and Norway's Noraqua company. The company's owners intended to supply 500,000-700,000 smolts to salmon farms in Norway, but those farms were already fully supplied by Norwegian hatcheries. Because of the difficulty in obtaining credit in Iceland, Islandlax was unable to finance the raising of salmon to market size, and went bankrupt with debts of $18 million.

Despite such setbacks, many Icelandic farmers are successfully making the transition from production of smolts to production of market-sized salmon. Icelandic salmon farmers have emphasized strict standards in their industry, seeking to present their fish on world markets as unsurpassed in quality and free of all chemical additives. Salmon ranching is particularly popular in this context, since it allows farmers to harvest salmon which have matured in the pristine waters surrounding Iceland. Salmon ranching is expected to yield 1,000 t of salmon per year as of the mid-1990's.

Icelandic farmers have benefited in the past from the technical experience brought in by foreign investors, particularly from Norway, but have lately begun to develop their own technical base. In 1986, the first class of aquaculturists was graduated from Iceland's Agricultural College, and was reported to be in great demand among Icelandic salmon farmers.

Exports

In 1988, Iceland exported 75 percent of its farmed salmon production (Table 5). Exports to the United States, Iceland's largest market for farmed salmon, benefit from air transport links which allow salmon harvested in the morning to be on sale in New York by the next morning. Iceland also flies fresh salmon to Europe, where the largest market is France, and has recently added air transport service to Japan. In 1989, preliminary estimates indicated that Iceland exported between 1,500 and 2,000 t of salmon, thus doubling the quantity of its 1988 exports.

Table 5.—Iceland's exports of farmed salmon by country of destination in amount (t) and value ($1,000), 1988.

Destination	1988 Amt.	1988 Value	Destination	1988 Amt.	1988 Value
United States	370.5	2,767	Denmark	8.1	52
France	232.9	1,344	Belgium	2.0	11
Switzerl.	59.2	531	Spain	0.3	2
Japan	53.5	452	Hong Kong	0.2	2
F.R.G.	32.6	241	Italy	0.1	1
UK	32.0	186	Sweden	0.1	1
Netherl.	27.8	182	Total	819.4	5,772

Outlook

As of early 1989, sources in Iceland indicated that production of farmed salmon would continue to increase at a rapid rate, doubling from 3,900 t in 1989 to over 8,000 t in 1990. The rash of salmon farm bankruptcies in late 1989 may slow the production increase somewhat.

Sweden and Finland

Sweden and Finland both farm the Atlantic salmon, but at relatively low levels. Swedish farms produced 363 and 600 t (est.) in 1988 and 1989, respectively, while Finland harvests for the same years were just 150 and 170 t (est.).

Swedish Production

Swedish salmon farming contrasts sharply with salmon culture in Norway, where salmon farming is a major industry. There are few salmon farms in Sweden (about 15 in 1987); most are small family enterprises on the east coast. About 2 million salmon smolts are raised in Swedish hatcheries each year, but most are released into rivers for stocking purposes rather than raised by farmers. Swedish fishermen catch about 1,000 t of wild salmon in the Baltic each year,

and the Government is more concerned about maintaining wild stock levels than about increasing salmon farming. Salmon farms receive no significant Government aid.

Although salmon farming is not a priority in Sweden, several farmers have introduced innovative production methods. In 1986, farmers tested a "Semi-Submersible Offshore Farm" in the North Sea. The capability to produce salmon offshore may be important to the future of aquaculture in Sweden, where concern for protection of coastal areas is strong. Other innovations involve the species being farmed. One Swedish company is successfully producing Arctic char, *Salvelinus alpinus*, which is considered more difficult to raise and potentially more profitable than other members of the salmon family.

Finnish Production

Finland's production of farmed salmon is small, hardly reaching commercial levels. Finnish salmon farmers began by producing smolts for export to rapidly expanding Norwegian salmon farms. While its inland waters are ideal for raising smolts, raising adult salmon in Finland has been more difficult because its coastal waters are quite cold. The Gulfstream, which warms the coastal waters of both Scotland and Norway, does not reach Finland. Another difficulty for salmon farmers is the low salinity of the Baltic Sea.

In recent years, as exports of salmon smolts to Norway declined—especially when Norway temporarily suspended all smolt imports for fear of disease—farmers have attempted to develop their own salmon farming capacity, despite technical difficulties. Finland has also joined Sweden in releasing salmon smolts into the Baltic in an effort to rebuild wild stocks. In 1986, scientists at the State Central Fish Culture Station in eastern Finland began work on a salmon ranching project in which released smolts would return to the hatchery. Finnish farmers have also successfully attempted to raise chum salmon and Arctic char.

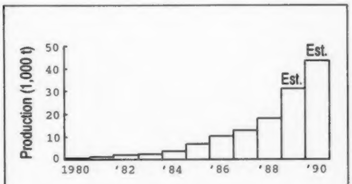

Figure 7.—United Kingdom farmed Atlantic salmon production (live weight), 1980-90.

UK: Scotland

Production

Scotland's production of farmed Atlantic salmon—second only to Norway's—has increased steadily since the mid-1980's (Fig. 7). Salmon production expanded from about 18,000 t in 1988 to an estimated 31,000 t in 1989 and was forecast to exceed 43,000 t in 1990. Fish farmers in Scotland have had considerable success overcoming the many technical problems involved in commercial salmon farming. The Scottish industry, however, faces marketing difficulties because of the tremendous growth in farmed salmon supplies to the EC during 1988-89. As salmon exports from Norway have increased, prices throughout the EC have fallen. At two of the largest wholesale fishery markets in Europe (Billingsgate in London and Rungis near Paris) salmon prices fell below those of cod in mid-1989.

For Scottish salmon farmers, whose product has enjoyed a reputation for high quality and high price, the prospect of lower prices in both domestic and foreign markets is discouraging, but not catastrophic. Although several farms closed in 1989, others opened or expanded. Farmers have continued to introduce more sophisticated production methods. Smolts are vaccinated against diseases and are often airlifted to farms by helicopter.

Instead of introducing measures to limit the expansion of salmon production, as Norwegian farmers have begun to do recently, Scottish farmers seem to be betting that the market for their salmon will continue to expand. Andrew Gray, the marketing director for the Scottish Salmon Board, states that production will be allowed to expand to 55,000-65,000 t by 1992. Unless world markets expand more than expected, he says, production will not be increased beyond that level.

Farms

Most UK salmon farms are located in northwest Scotland, where bays and islands provide sheltered sites. There are also farms on the east coast and on the Shetland Islands. In 1988, there were 153 companies operating 258 farms, compared to 126 companies and 196 farms in 1987. The majority of these farms used sea-cages, though 14 sites used shore-based tanks or raceways. Of the almost 18,000 t of salmon harvested in 1988, 12,000 t were from smolts received in 1987 and 6,000 t from 1986 smolts. The 22.5 million smolts produced in 1988 were supplied by 90 companies operating 176 sites. Smolt production was expected to reach 28.7 million in 1989, and 33.6 million in 1990.

Many early investments in Scottish aquaculture were made by the Dutch-owned Unilever company, through its Marine Harvest subsidiary. As early as 1986, Marine Harvest had invested $20 million in Scotland, operating 3 salmon hatcheries, 4 freshwater smolt farms, and 18 salmon culturing farms. By 1988, Marine Harvest produced an estimated 5,500 t of farmed salmon. In 1989, the company expanded its processing plant and expected to harvest 8,000 t of salmon, or about 25 percent of the entire UK production.

Farmers in the Shetland Islands pro-

duced a record 8,000 t of salmon in 1989, a 74 percent increase over 1988. The salmon harvest was valued at an estimated $44 million, $11 million more than the value of the entire 1989 pelagic and groundfish catch off the Shetlands. Even so, salmon farmers in the Shetlands felt the effects of lower prices on European markets. The value of their record harvest increased only by one-third over 1988 levels.

Exports

Most salmon produced in the UK is consumed domestically. In 1988, UK salmon farmers exported 36 percent of their harvest, with a value of $52 million (Table 6). France was the largest export market, followed by the Netherlands. The United States imported $4 million worth of farmed salmon from the UK in 1988. Importers in the United States reportedly hold Scottish salmon in high regard, but have recently begun to resist the higher prices that UK exporters charge. According to some U.S. importers, UK exporters still have to adjust to lower world salmon prices.

In 1989, salmon farmers in the UK increased their exports significantly when production increased by 14,000 t. However, the even larger 1989 production increase in Norway (about 26,000 t) boosted supplies of salmon in the EC market. Prices fell sharply. As discussed previously for Norway, Scottish salmon farmers helped persuade the EC Commission to investigate alleged dumping by Norwegian salmon exporters.

Outlook

The rapid increase in Scottish farmed salmon production in recent years has forced farmers to reevaluate their marketing strategy. According to William Crowe, of the Scottish Salmon Growers Association, Scottish farmers have decided to commit themselves to mass production of increasing quantities of salmon for larger markets, instead of continuing to promote their product as the handcrafted "Rolls Royce" of farmed salmon. To market their increased output, Scottish salmon farmers plan to enlarge their overseas markets in the United States and in Japan.

Ireland

Production

Irish production of farmed salmon has increased markedly each year since the mid-1980's and is expected to reach 10,000 t in 1990 (Fig. 8). Production was 4,200 t in 1988 and an estimated 7,300 t in 1989. The Irish Salmon Growers Association is developing a two-part strategy for its expanding industry: 1) A quality assurance program under which each harvested salmon will carry a special gill tag indicating that it has been inspected and 2) a marketing plan targeted at the United States and Japan. Salmon farms in Ireland received $5 million in EC aid in 1988. Assistance is also provided by the Government's Irish Sea Fisheries Board and Udaras Na Gaeltachta—the latter offers aid to Gaelic speaking areas of Ireland. In 1988, a disease called infectious pancreatic necrosis infected Irish farmed salmon. Farmers estimated that 25 percent of their harvest was lost that year because of the disease. The disease was not a problem in 1989.

Farms

Only 21 salmon farms were operating in Ireland in 1988, but interest in salmon farming runs high. The Irish Department of the Marine had over 600 aquaculture applications under review in 1989. However, after several years of rapid expansion, salmon farming in Ireland is facing growing resistance from conservationists, representatives of the tourist industry, and recreational fishermen, all of whom oppose the use of picturesque coastal sites for salmon farms and hatcheries.

Because of this resistance, some salmon farms are moving offshore. In 1983, the Irish farmers purchased their first Bridgestone Hi-Seas Cage, manufactured in Japan. By 1989, Irish culturists were operating 28 such cages, becoming the world's largest user. In October 1989, Ireland inaugurated an ambitious 25,000 m^3 floating salmon farm, said to be able to produce 400 t of salmon per year.

In 1989, there were 25 Irish companies raising smolts at 32 sites, producing an estimated 9.7 million smolts. This was a significant increase from the 6.9 million smolts raised in 1988. Government licenses are required for freshwater hatcheries, and Government grants are available to finance as much as 65 percent of capital costs.

Exports

Irish farmers exported 2,300 t of salmon, worth over $16 million, in 1988 (Table 7). France was the largest im-

Table 6.—United Kingdom exports of farmed salmon by country of destination, 1988.

Destination	1988 Quantity (t)	1988 Value ($1,000)
France	4,281.0	31,757
Netherlands	648.0	5,889
United States	341.0	4,024
Other	1,237.0	10,343
Total	6,507.0	52,013

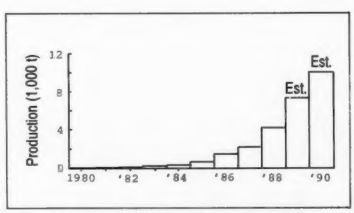

Figure 8.—Ireland's farmed Atlantic salmon production (live weight), 1980-90.

Table 7.—Ireland's exports of farmed salmon by country of destination, 1987-88.

Destination	1987 Quantity (1,000 t)	1987 Value ($1,000)	1988 Quantity (1,000 t)	1988 Value ($1,000)
France	1,124	7,206	1,610	10,927
U.S.A.	41	411	267	2,345
UK	365	2,238	185	1,238
Netherl.	27	218	128	1,053
Belg.-Luxem.	63	519	55	433
Spain	75	552	46	316
Japan	17	181	21	141
F.R.G.	9	73	4	52
Switzerl.	2	22	2	12
Denmark	0	0	1	6
Others	10	90	0	2
Total	1,733	11,510	2,319	16,525

porter of Irish salmon, both because of its relative proximity to Ireland and because French consumers prefer the small (1-2 kg) salmon produced in Ireland. Other EC nations accounted for most of Ireland's exports of farmed salmon, but the United States also imported significant quantities, increasing its imports from 40 t in 1987 to almost 270 t in 1988.

Outlook

Irish salmon farmers intend to produce 30,000 t of farmed salmon per year by 1995, but some observers in Ireland are questioning that goal. Decreasing world prices for farmed salmon are a long-term concern. Despite the glut of Norwegian farmed salmon on the market, the Irish Salmon Growers Association maintains that the industry can afford to continue its rapid expansion if it focuses on the large markets in the United States and Japan.

France

French salmon farmers produce varied amounts of both Atlantic and Pacific salmon. Production in 1988 was just 60 t but for 1989 it was estimated to be 600 t.

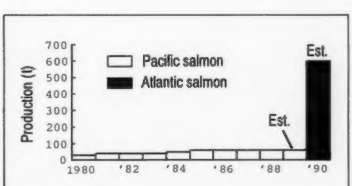

Figure 9.—French farmed salmon production (live weight), 1980-90.

Production

French aquaculturists have emphasized shellfish production (oysters and mussels). Even though it is one of the world's largest salmon importers, France has made no overwhelming effort to become self-sufficient in salmon production, depending instead on imports from North America, and more recently, from Norway and Scotland. In recent years, farmers in Brittany (northwest France) have succeeded in raising trout on a commercial scale, producing about 500 t per year. Pacific coho salmon have been produced at some of the same farms, but on a much smaller scale (Fig. 9). Farmers who have attempted to raise salmon in French waters have reported low survival rates during the summer months when water temperatures rise. Scientists at the National Institute for Agronomy Research (INRA) and the Institut Français pour la Recherche et l'Exploitation de la Mer (IFREMER) are currently investigating the technical aspects of salmon farming in warmer waters, but there is no indication that France will become a major producer of salmon in the foreseeable future.

Farms

The first French farm dedicated exclusively to Atlantic salmon production began operation in mid-1989, when about 230,000 smolts were delivered from Norway to the barge *Ile Sous le Vent*, a converted Portuguese oil tanker. The vessel is the first known conversion of a tanker for use as a salmon farm. The 116 m long floating farm, equipped with four 4,000 m^3 holds, is anchored about 5 km off the north coast of Brittany in Morlaix Bay. Capacity is limited to 500,000 smolts which should yield about 600 t of salmon in 1990. Future harvests from this $10 million farm are expected to reach 750 t per year. Another converted oil tanker was due to arrive in the Bay in 1990, bringing potential production levels to 1,500 t annually. However, local environmental groups are seeking to limit the expansion of this salmon farming project.

Other French firms are interested in raising farmed salmon as well. In Plouguerneau, the Fermor company plans to establish a salmon farm that will produce 300 t of salmon annually. The Bouygues group plans to establish a 1,000-2,000 t annual capacity farm off Camaret. Six 30 m diameter cages will be linked to a central tower. If the sea gets too rough, the cages will be lowered to a depth of 20 m. Overseas, the French Regional Association for the Development of Aquaculture (ARDA) has helped establish Atlantic salmon farms on the islands of St. Pierre and Miquelon, off Canada.

Spain

Production

Spanish Atlantic salmon farming exists only on a very small scale (Fig. 10). In contrast to its large trout farming industry, Spain's salmon farms only produced about 300-500 t per year during 1988-89. As in France, salmon farmers

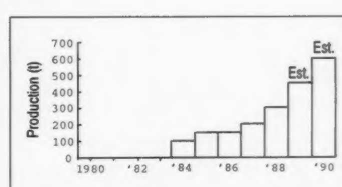

Figure 10.—Spanish farmed Atlantic salmon production (live weight), 1980-90.

have faced difficulties because of Spain's relatively warm waters.

Norwegian investors announced plans to establish several salmon farms in northern Spain in 1988. The Norwegians believed that technical difficulties could be overcome, and were interested in gaining access to Spain's growing salmon market. Current information on these farms was not available, but the Spanish market for salmon and trout is indeed expanding. In 1988, salmon and trout imports (aggregated in Spanish trade statistics) increased to 7,300 t from 4,300 t in 1987.

Canada

Canada farms both Atlantic and Pacific salmon, including several species of the latter. Total output in 1988 was 9,100 t, while 1989 harvests were projected to hit 16,700 t.

Production

Canadian salmon farmers forecast a harvest >23,000 t in 1990, continuing the rapid increase in production that began in the mid-1980's (Fig. 11). In 1985, production on both coasts was <500 t. Since then, salmon farming on the Pacific coast (in British Columbia) expanded to an estimated 14,500 t in 1989, while farming on the Atlantic coast (primarily in the Bay of Fundy between Nova Scotia and New Brunswick) increased more slowly to about 3,000 t. The growth of Canadian salmon farming was helped by considerable Norwegian investment.

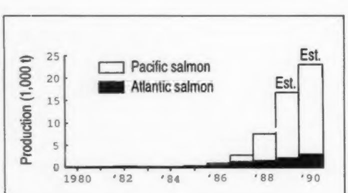

Figure 11.—Canadian farmed salmon production (live weight), 1980-90.

Pacific Region

Salmon farmers in British Columbia (B.C.) raise mostly Pacific species, including chinook (3,850 t in 1988), coho (2,000 t), and chum salmon 150 t). Chinook salmon farming is expanding in response to consumer preferences in the United States—Canada's largest export market. Chinook production in B.C. was projected to reach 16,500 t in 1990.

Salmon farmers in B.C. were said to have adopted a "gold rush" mentality in the mid-1980's, as farms were established with little regulation or coordination. More recently, however, both Government and private organizations have begun to play an important role in the development of the region's aquaculture industry. The B.C. Salmon Farmers' Association (BCSFA) now represents 95 percent of Pacific salmon farmers and has established well recognized health and quality standards. The BCSFA also performs marketing studies intended to maximize returns to farmers. A privately funded salmon research institute, Ewos Pacific Research Farm, began investigating nutrition and health issues in mid-1989.

The B.C. Government has moved to supplement these private regulatory and research efforts by forming the B.C. Aquaculture Research and Development Council in 1989. A 1988 "Memorandum of Understanding" between the B.C. Government and the Federal Department of Fisheries and Oceans clarified Federal and provincial responsibilities for aquaculture.

Atlantic Region

Salmon farms in Atlantic Canada—producing Atlantic salmon—are centered in the "Scotia-Fundy" region located northeast of Maine. Salmon aquaculture in this region has grown at an orderly pace—in contrast to B.C.—but has also expanded more slowly than predicted. Provincial authorities in Nova Scotia and New Brunswick have adopted a cautious attitude, apparently to prevent overexpansion of the industry. The New Brunswick Government placed a moratorium on the issuance of salmon farm licenses during 1986-88 and has issued only limited numbers of licenses since then. Thus, current production levels (about 3,000 t) are not expected to increase rapidly. Even so, salmon culture in Atlantic Canada was reportedly generating C$40 million per year in direct sales by 1988.

Salmon farms in Quebec and Newfoundland have so far produced only about 100 t of salmon per year. In an effort to determine whether higher production levels could be achieved in these coldwater areas, researchers recently conducted a 3-year experiment in Newfoundland involving in-cage heating systems and different species of salmon. The commercial feasibility of the experimental farming methods is now being evaluated.

Farms

In 1989, there were 150 active salmon farms in B.C. (200 licenses had been issued), producing an average of 100 t each. The largest concentration of farms is on the west coast of Vancouver Island. Most farmers raise salmon by using smolts from separate Government or private hatcheries, but some farmers are integrating their operations vertically by building hatcheries.

There were about 45 salmon farms operating in Atlantic Canada in 1989, most of them in the Bay of Fundy. Average annual production per farm in this region is lower than in B.C.—about 65 t. Many of the farms in Atlantic Canada are quite small; there are only a few large-scale operations. Connors Brothers company, a leading sardine canner, operates a salmon farm and a 400,000-smolt hatchery in New Brunswick, supplies fishmeal to many salmon farmers in the area, and markets salmon for other

farmers. The Sea Farms company, a Canada-Norway joint venture, operates 3 hatcheries and 3 farms which are expected to produce 1,000 t of salmon per year by 1990.

Exports

Unlike most other major salmon farming nations, Canada also operates a large wild salmon fishery. Export statistics do not explicitly distinguish between the two sources of salmon. In 1988, exports of fresh salmon from B.C., presumably including most farmed salmon, were shipped mainly to the United States (5,200 t, C$33.1 million in 1988), followed by Japan (290 t, C$3.0 million), and the UK (80 t, C$0.5 million). Corresponding statistics for Atlantic Canada were not readily available. In 1989, the United States imported about $45 million worth of fresh salmon from Canada, including $22 million worth of Atlantic salmon (3,000 t), $12 million worth of sockeye (2,400 t), $8 million worth of coho (1,900 t), and $3 million worth of pink salmon (1,700 t).

Outlook

In 1989, Canada's Fisheries and Oceans Minister, Tom Siddon, announced the release of a report entitled "Long Term Production Outlook for the Canadian Aquaculture Industry," prepared by the Price Waterhouse company. The report forecasts a "worst-case" farmed salmon production level of 31,000 t by the year 2000, and a "best-case" level of 66,000 t.

Japan

Japan is the world's largest market for salmon and the largest salmon importer. Only species of the Pacific salmon are cultured. Production in 1988 was 16,400 t and in 1989 it was estimated at 18,600 t.

Production

With its enormous market, Japan has attempted to maintain a high level of self-sufficiency in salmon supplies. As salmon fishing quotas in the North Pacific (established jointly by the Soviet Union and Japan) have been reduced in recent years, Japan has turned to two artificial methods for increasing the supply of salmon. The first method—employed on a small scale since the 1940's—involves hatching and releasing salmon fingerlings, which are then caught several years later off the coast of Japan. This type of salmon ranching yielded 155,000 t of salmon in 1986, a 2.5 percent return rate on the 2 billion fingerlings released in 1982. The second method, coho and chinook salmon culture in sea cages, has not yet yielded comparable quantities of salmon, but it has reached significant levels in recent years (Fig. 12).

Japan's farmed salmon production has increased from 5,000 t in 1984 to an estimated 18,600 t in 1989, making Japan the world's third largest producer of cultured salmon and the largest producer of Pacific species. Unlike most other salmon producing countries, Japan apparently does not export any of its growing salmon harvests, and thus has not contributed to the recent rapid growth of farmed salmon supplies on world markets. Nevertheless, Japan's increasing salmon farming capacity may affect its import requirements, especially for fresh salmon. Production would have to increase dramatically to completely supply Japan's salmon market: In 1989, Japan imported over 135,000 t of fresh, chilled, and frozen salmon (mostly frozen Pacific species).

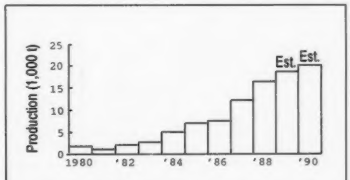

Figure 12.—Japanese farmed Pacific salmon production (live weight), 1980-90.

The Japanese Government has not played a decisive role in the establishment of the salmon farming industry, leaving its development to private companies. Partly for this reason, official information about Japanese salmon farming is limited. A nongovernment agency, the Japan Fishery Resources Conservation Association, inspects most shipments of salmon eggs imported into Japan to prevent the spread of whirling disease or viral hemorrhagic septicemia.

Salmon Farms

Most commercial-scale salmon farms in Japan produce coho salmon; smaller farms produce other species, including chinook. There were an estimated 377 coho salmon farms active in Japan in 1989, compared to 326 farms in 1988. Most of these farms (329) are located in Miyagi Prefecture, about 200 miles north of Tokyo. Smolts are supplied by about 130 freshwater farms, using fertilized coho eggs imported primarily from the United States.

Nichimo Fishing Corporation, a major Japanese company, built the first Japanese salmon farm in the early 1970's, prompted by the decline in North Pacific salmon fishing quotas. The company has continued to be the leading producer of coho salmon, and has recently begun to produce cherry salmon, chinook salmon, and hybrid salmon species. In addition, the company is attempting to reduce dependence on imported eggs; it has successfully raised salmon from eggs hatched in Japan. Other important salmon farming companies include Nichiro and Taiyo. The Mitsubishi Corporation has recently joined the Niigata Iron and Steel Company and the Hokkaido Prefectural Fish Hatchery in a feasibility study of raising Atlantic salmon.

Outlook

Japanese production of farmed Pacific salmon will continue to increase. Coho

egg imports from the United States, which largely determine coho salmon production with 2-3 years lag, increased from 28 million in 1986-87 to 44 million in 1988. If past production rates continue, this level of coho egg imports could yield as much as 30,000 t of salmon in 1990 or 1991.

Chile

Chile is another nation that farms both Atlantic and Pacific salmon species. The harvest for 1988 totalled 3,100 t, and for 1989 the total was estimated at 6,508 t.

Production

Chilean salmon growers expected to harvest over 12,000 t of farmed Atlantic and Pacific salmon in 1990, double the estimated 6,500 t harvested in 1989 (Fig. 13). Salmon culture is Chile's fastest growing economic activity. At current growth rates, the salmon culture industry could well become the leading sector of the country's dynamic fishing industry, supplanting Chile's massive fishmeal industry. Salmon farmers initially cultured Pacific coho salmon, but the involvement of Norwegian and British companies has made possible diversification into Atlantic salmon. Many farmers are also working with Pacific chinook salmon and sea-farmed trout ("salmon-trout"). Harvests of sockeye and cherry salmon are also planned.

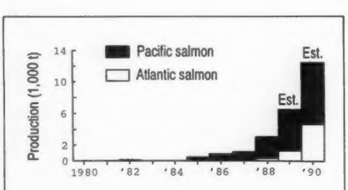

Figure 13.—Chilean farmed salmon production (live weight), 1980-90.

Salmon culture is a new industry in Chile. Farmers first harvested more than 1,000 t as late as 1987. Several large foreign companies have subsequently entered the industry, permitting substantial production increases. The participation of major salmon culture companies from Norway, the UK, and Japan has meant an infusion of technology and capital which is enabling the Chilean industry to evolve rapidly from a small-scale operation to an increasingly important sector of the country's fishing industry. Harvests in 1993 could be close to 30,000 t, equivalent to current UK salmon production levels. Some observers believe that the Chilean industry will eventually rival the massive Norwegian industry. Chilean production costs are generally below those of its major competitors, primarily because of lower feed costs· Chile is a major fishmeal producer.

Farms

The Chilean coast is similar to the Norwegian coast, with large numbers of well sheltered sites which are ideally suited for salmon farms. Many additional sites are still available along the coast south of Chiloe Island, where the industry is now centered. Farmers are reporting excellent yields with growth rates exceeding some of the best Scottish and Norwegian operations. (The latitude of Chiloe Island is about 40 degrees, compared with Oslo's latitude of about 60 degrees.) Salmon farmers still rely heavily on imported fertilized salmon eggs, but a small domestic smolt-producing industry is developing. An estimated 25 companies produced salmon smolts in 1989. Salmon farmers in Chile hope to develop a "native species" of disease-resistant farmed salmon.

Table 8.—Chile's exports of farmed salmon by country of destination, 1986-88, by value.

Destination	Exports ($1,000) 1986	1987	1988
United States	3,237	5,000	9,232
Japan	120	83	7,561
Netherlands	0	57	979
France	6	0	834
Brazil	103	100	259
Argentina	68	107	189
Italy	0	34	136
Belgium	0	25	12
Canada	41	0	0
Others	11	30	398
Total	3,586	5,436	19,600

Exports

Chilean salmon farmers initially marketed their harvests largely fresh in the United States. In 1988-89, however, exports to Japan increased markedly (Table 8 for 1988). In 1989, Chilean exports of frozen salmon to Japan reached 3,970 t, worth $24 million. Prospects for European sales are unfavorable because of relatively high freight charges to Europe and competition with European producers.

Outlook

Even in an environment of declining prices, Chilean salmon producers are well situated to compete successfully because of their low cost structure, high quality standards, species diversification, and successful penetration of both the Japanese and U.S. markets.

New Zealand

Salmon farming in New Zealand is a relatively new industry, and it is limited

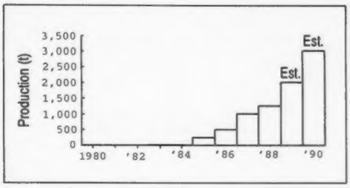

Figure 14.—New Zealand farmed Pacific salmon production (live weight), 1980-90.

to culture of Pacific salmon, largely the chinook. The first salmon farm was established in 1978. Many farmers began to raise salmon on a small scale after first operating other aquaculture ventures such as mussel farms.

Production

New Zealand's salmon production has increased rapidly in recent years (Fig. 14). While it has yet to become a major producer, New Zealand's salmon output is significant because farmers produce commercial quantities of chinook salmon, a species which is not yet farmed on a large scale anywhere else except in Canada. Exact figures for production by species are not available, but in 1988, production was 1,250 t, while in 1989 New Zealand's salmon farms reportedly had the capacity to produce 2,000 t of chinook salmon per year.

Farms

There were about 43 salmon culture operations in New Zealand as of early 1988, the latest year for which data were available. Of these, 12 were ocean ranches, 15 were sea-cage farms, 15 were fresh-water pond farms, and 1 was an onshore seawater farm. Most farmers and ranchers raised chinook salmon. At least 9 farms also produced sockeye salmon, but output had not yet reached commercial levels. All farms are licensed by the Government. Eggs are provided primarily by the New Zealand Salmon Company's hatchery, which produces up to 10 million eggs per year.

Salmon farmers in New Zealand have faced both natural and man-made obstacles to expansion. In early 1989, about 600 t (out of a total of 1,400-1,500 t of penned chinook salmon) were lost after an algae bloom struck a group of farms on Stewart Island, the center of the salmon farming industry. On that occasion, farmers were hindered in their efforts to save stocks by a Government regulation restricting salmon farms to Glory Bay, where the algae bloom was most pronounced. After these serious losses, farmers petitioned the Government to relax some of the restrictions placed on salmon farms. However, the control of salmon farming remains a sensitive issue in New Zealand, where protecting the environment is a priority. Ironically, the algae bloom which destroyed a significant portion of salmon stocks in early 1989 also heightened concerns that salmon farming had disturbed the natural environment. (Later research, however, has apparently shown that the algae infestation was caused by natural conditions.) Despite the irritation that salmon farmers express concerning strict controls on their industry, Government regulations have played a role in protecting New Zealand's salmon farms from disease outbreaks. Farms have been briefly quarantined after salmon were discovered to have whirling disease.

Apart from regulatory control, another factor in the slow growth of New Zealand's salmon farming capacity is opposition from native peoples, such as the Maoris, who own prime coastal land. Potential salmon farming ventures have faced long bureaucratic delays as applications for leases are reviewed.

Exports

Most of New Zealand's salmon production is exported to the United States and Japan. In 1986, 75 percent of its exports were sold to the United States, but in recent years the emphasis has shifted overwhelmingly toward Japan. In 1989, New Zealand exported 960 t, worth $5.6 million to Japan, but only about 1 t to the United States. Most exports are shipped frozen, rather than fresh.

New Zealand's southern-hemisphere location is advantageous for salmon exports, because—like Chile—its harvests are available during the northern hemisphere's salmon culture off-season (June-

August). Furthermore, by producing chinook salmon, New Zealand's farmers have entered a market in which there is limited competition from other salmon farming nations. On the other hand, New Zealand's salmon exporters face the disadvantage of high transport costs.

Australia

Salmon farming in Australia began in 1985 when the Tasmanian Government and Norway's Noraqua Group established a joint venture (called Tassal Ltd.) to produce Atlantic salmon, still the only species. That company has become the country's largest producer, and other Atlantic salmon farms have opened both in Tasmania and in western Australia. The prospects for development of salmon farming in Australia are good because of favorable natural conditions and because of the presence of experienced farmers from both Norway and Scotland. In addition, many salmon farmers in Australia have experience in raising trout and are thus prepared for some of the difficult technical issues involved in raising salmon.

Production

Most farmed salmon in Australia is sold on the domestic market. In 1989, however, Australia exported 280 t, worth $3 million, to Japan. Salmon production for 1988-89 was 380 t total, and for 1989-90 it was estimated at 2,000 t.

Farms

Australian salmon farms are concen-

trated on the island of Tasmania, south of the mainland, where natural conditions favor rapid growth. In 1987, the latest year for which data are available, there were 26 farms licensed to raise salmon in Tasmania (and 23 farms were licensed to grow rainbow trout). The 4 largest farms on the island are operated by the Tassal company, the joint venture with Norway, which has established an integrated operation controlling production from the smolt stage through harvesting, processing, and marketing.

At least two companies—the Marine Industries company and the Australian Seafarms company—have opened salmon farms on the southwest coast of Australia, near Perth. Marine Industries operates tank farms for production of rainbow trout and was planning to use a similar system for production of salmon. In 1987, that company was forecasting harvests of about 500 t per year by 1992, while Australian Seafarms was forecasting production of 300 t per year by 1991 and 1,000 t per year by 1994. Actual production figures for the companies were not available as this report was being prepared.

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Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, the *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

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